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ORIGINAL ARTICLES.

1.—On the Lower Devonian Fish-Fauna of Campbellton, New Brunswick.

By Arthur Smith Woodward, F.L.S., F.G.S.

(PLATE I.)

THE Lower Devonian Fish-Fauna of Campbellton, New Brunswick, has already been described by Mr. Whiteaves,[1] of the Canadian Geological Survey, and Dr. Traquair,[2] of Edinburgh; and a few supplementary observations are published in the British Museum Catalogue of Fossil Fishes, Part II. (1891). Much, however, still remains to be learned concerning the skeletal anatomy of the genera and species already determined; and many types of early fishes will doubtless soon be discovered by future explorers of the formation and locality in question. A new series of specimens just received by the British Museum from Mr. R. F. Damon, of Weymouth, adds some small items of interest to our knowledge of the subject; and the following notes relate to the advance thus made. The fossils under discussion were collected last summer by Mr. Jex, and are all much crushed and flattened in the usual manner.

ELASMOBRANCHII.

Genus Protodus, nov.

A genus known only by detached teeth. Dental crown consisting of a single robust, solid, conical cusp, invested with gano-dentine; root large, undivided, laterally expanded, and antero-posteriorly compressed.

That the tooth thus defined is not the laniary of a Crossopterygian attached to its basal bone is proved by the examination of a microscopical section, which leaves little doubt as to its Elasmobranch relationships. *Protodus* is thus the earliest tooth referable to the Elasmobranchii hitherto determined, and is especially remarkable on account of the form of the root. There is much reason to believe that all the more primitive Elasmobranch teeth possess a horizontally expanded base (or root), while antero-posterior compression is the

[1] J. F. Whiteaves, Canadian Naturalist, n.s. vol. x. (1881), pp. 93–100; also "Illustrations of the Fossil Fishes of the Devonian Rocks of Canada, Part II.," Trans. Roy. Soc. Canada, vol. vi. sect. iv. (1889), pp. 92–96, pl. ix. pl. x. figs. 2–4.

[2] R. H. Traquair, "Notes on the Devonian Fishes of Scaumenac Bay and Campbelltown in Canada," Geol. Mag. [3] Vol. VII. (1890), pp. 20–22; also "On *Phlyctænius*, a New Genus of Coccosteidæ," *ibid.* pp. 55–60, pl. iii.

result of specialization. Such being the case, *Protodus* is a specialized form of a very simple type of tooth.

1. *Protodus Jexi*, sp. nov. Pl. I. Figs. 1, 1*a*.

Crown of tooth attaining a height of about 0·005, and measuring 0·003 in width at the base; the apical half sharply bent inwards; coronal surface smooth, the lateral margins keeled, both faces convex, and the outer face with an unsymmetrically placed longitudinal ridge imparting to the tooth a twisted appearance. Root compact, stouter and much less deep than the crown.

The best-preserved specimen is shown of the natural size in Pl. I. Figs. 1, 1*a*, and there are four more imperfect examples in the collection. The specific name is suggested in honour of Mr. Jex, of Weymouth, to whose skill in collecting so many remarkable discoveries of Devonian and Carboniferous fishes, both British and Canadian, are due.

Genus Diplodus, Agassiz.

[Poiss. Foss. vol. iii. 1843, p. 204.]

Teeth of this form are now known to be common to several genera of primitive Elasmobranchs, already discovered in formations ranging from the Lower Carboniferous to the Upper Trias. A unique specimen in the new collection of Lower Devonian fish-remains from Campbellton now seems to show that the same type of tooth occurred in certain Elasmobranch Fishes even in the early portion of the Devonian period; and the discovery of parts of the skeleton of these ancient forms will be awaited with considerable interest.

2. *Diplodus problematicus*, sp. nov. Pl. I. Fig. 2.

The single tooth referred to appears to be destitute of the root and exhibits only the outer face of the crown. It is shown of three times the natural size in Pl. I. Fig. 2. The two principal cusps are well separated, unequal in size, and widely divergent; each being long and slender, somewhat tumid in the basal portion, and attenuated distally. The median cusp or denticle is subulate, long and slender. The gano-dentine is quite smooth.

Though several forms of "*Diplodus*" are known to occur in one and the same mouth of some Pleuracanth fishes, and the recognition of specific characters in detached teeth thus becomes impossible; it still seems advisable to adopt provisional names for isolated examples, and the Lower Devonian tooth described above may thus be known as *Diplodus problematicus*. More especially does this name appear to be appropriate, as the form of the root and the microscopical structure of the tooth yet remain to be determined.

Genus Gyracanthus, Agassiz.

[Poiss. Foss. vol. iii. 1837, p. 17.]

3. *Gyracanthus incurvus*, Traquair. Pl. I. Figs. 4, 5.

1890. R. H. Traquair, Geol. Mag. [3] Vol. VII. p. 21.

A small, much arcuated, and laterally compressed spine, attaining a length of about 0·065. Anterior border acute; posterior border

with a single regular series of closely arranged, small stout denticles. Lateral ornamentation delicate, consisting of numerous sharp ridges, disposed with a very slight obliquity, which increases towards the base and towards the anterior border; the ridges coarsest and most widely spaced at the base and at the anterior border, sometimes smooth, sometimes in part crenulated.

Four examples of this interesting ichthyodorulite are contained in the new collection from Campbellton, and the finest specimen is shown of the natural size in Pl. I. Fig. 4. The fossil is imperfect in the basal half, though exhibiting all the principal characters of the species; and the sharp oblique line of demarcation between the inserted and exserted portions is conspicuous. Another specimen seems to show distinct abrasion of the apex (Pl. I. Fig. 5), such as is a well-known feature of the typical Carboniferous *Gyracanthus*; and a third fragment has been sliced transversely to obtain a microscopical section. The central cavity of the spine is thus proved to to have extended far towards the apex, and the tissue consists wholly of vaso-dentine.

Genus Climatius, Agassiz.

[Poiss. Foss. V. G. R. 1845, p. 119.]

4. *Climatius latispinosus*, Whiteaves, sp.

1881–89. *Ctenacanthus latispinosus*, J. F. Whiteaves, Canadian Nat. n.s. vol. x. p. 99, and Trans. Roy, Soc. Canada, vol. vi. sect. iv. p. 95, pl. x. fig. 3.
1889. A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. iv. p. 183.

Numerous isolated spines of this large species of Acanthodian fish are contained in the collection. It is especially interesting to observe that in addition to the ordinary fin-spines already known, there are also some extremely broad and short triangular spines precisely similar to the intermediate ventral spines of the typical British species of *Climatius*. These are marked with radiating, sparsely tuberculated ridges, and their base of insertion is very narrow.

Genus Acanthodes, Agassiz.

[Poiss. Foss. vol. ii. pt. i. 1833, p. 19.]

5. *Acanthodes semistriatus*, sp. nov. Pl. I. Fig. 3.

Body much elongated and slender. Fin-spines much laterally compressed, with a single deep and broad longitudinal groove dividing each lateral face into a narrow smooth anterior area and a somewhat wider, finely striated posterior area. Pelvic fins situated nearer to the anal than to the pectorals, and the anal slightly in advance of the dorsal. Pelvic fin-spine apparently almost as large as the anal, and the latter much smaller than the dorsal. Scales smooth, the surface faintly excavated or flat.

The above definition is based upon a single imperfect fish (No. P. 6545) about 0·15 in length, and having the dorsal fin-spine 0·02 in length. Two large detached spines, however, remarkably similar to those of the type specimen, may probably be regarded as indicating that the species sometimes attained to much larger

dimensions; and one of these spines is shown of the natural s in Pl. I. Fig. 3.

A. semistriatus pertains to the primitive section of the ge (*Mesacanthus* of Traquair) already well known in the Lov Devonian, but attains to at least twice as large a size as any of congeners hitherto discovered.

OSTRACODERMI.

Genus Cephalaspis, Agassiz.

[Poiss. Foss. vol. ii. pt. i. 1835, p. 135.]

6. *Cephalaspis campbelltonensis*, Whiteaves. Pl. I. Fig. 6.

1881–89. J. F. Whiteaves, Canadian Nat. n.s. vol. x. p. 98, and Trans. Roy. S Canada, vol. vi. sect. iv. p. 92, pl. x. fig. 2.
1890. R. H. Traquair, Geol. Mag. [3] Vol. VII. p. 21.
1890. *Cephalaspis Whiteavesi*, R. H. Traquair, *ibid.* p. 21.
1891. A. S. Woodward, Catal. Foss. Fishes B. M. pt. ii. p. 190, pl. ix. fig. 5.

This is one of the commonest fishes in the Campbellton shale, b the specimens are almost invariably so much crushed and brok that the characters of the species are difficult to determine. T latest definition, given in the British Museum "Catalogue," see to be correct; and the examples of the head-shield in the n collection display only two features worthy of special note.

The most remarkable of these features—and one probably of mu significance—is the conspicuous difference between the structure the main part of the shield and that of the region termed the "po orbital valley." Whereas in shields that have lost the superfic layer, the tesseræ of the middle layer are well shown in every pa outside the "post-orbital valley," in this small area the tissue observed to be thickened and dense, with a splintery fracture, a without any sutures or conspicuous vascular canals. This harden plate, indeed, is so sharply separated from the surrounding shie that it has the appearance of an entirely independent element; a the writer is inclined to believe that some other Cephalaspidi shields in the British Museum, from the English Old Red Sandsto exhibit characters capable of a similar interpretation.

The tubercular nature of the superficial ornament of the shie is also noteworthy. One specimen shows well-separated round tubercles on the upper aspect of the cornua; and the inferior ri and rostrum of another specimen are marked with closely arrange flattened, irregularly stellate tubercles, sometimes almost fused in a network.

Finally, the new collection is interesting as comprising a sing specimen in which remains of the greater part of the squamation the trunk are preserved. The scales are unfortunately so mu crushed, broken, and displaced, that little of their arrangement c be determined; but their general appearance suggests that the were fewer deep and narrow scales than in the typical species which the trunk is well known. Many of the scales are near equilateral (Pl. I. Fig. 6), and exhibit a very narrow overlapp border. The hinder border is not serrated, but the unabrad

external face of the scale occasionally shows very delicate transverse rugæ. Abraded scales, as the one figured, are very conspicuously punctate, the pittings being arranged in transverse lines; and on the inner aspect there are but feeble traces of a vertical rib. On the whole, these scales are very suggestive of the so-called *Porolepis* from the Lower Devonian of Spitzbergen.[1]

In the imperfect head and trunk just referred to, the caudal extremity, with its small rhomboidal scales, is reflexed; and close to it, immediately in advance of the shield, there occur patches of a fine shagreen-like material. Of this there are further traces between the cornu and the squamation on the right side of the fossil. Though much finer than the calcifications in the azygous fin-membranes of the British species, the granules in question have probably served a similar purpose.

7. *Cephalaspis*, sp.

A very small imperfect Cephalaspidian shield from Campbellton, with well-separated tesseræ in the middle layer, differs from the corresponding shield of *C. campbelltonensis* in the relatively larger size of the denticles on the inner margin of the cornua. Unless this be a character of immaturity, the fossil thus indicates a distinct species. Fine granules mark the position of the opercular folds.

DIPNOI (*ARTHRODIRA*).

Genus PHLYCTÆNASPIS, Traquair.

[GEOL. MAG. [3] Vol. VII. 1890, pp. 60, 144.]

8. *Phlyctænaspis acadica*, Whiteaves, sp. Pl. I. Figs. 7, 8.

1881–89. *Coccosteus acadicus*, J. F. Whiteaves, Canadian Nat. n.s. vol. x. p. 94, woodc., and Trans. Roy. Soc. Canada, vol. vi. sect. iv. p. 93, pl. ix. and woodc.

1890. R. H. Traquair, GEOL. MAG. [3] Vol. VII. pp. 20, 60, Pl. III. figs. 1, 2.

Of several specimens referable to the type species of *Phlyctænaspis*, two are especially fine—one exhibiting the outer aspect of the head-shield, the other the inner or visceral aspect of the same. The former is shown of the natural size in Pl. I. Fig. 7, and of the latter the so-called "rostral" plate is separately represented in Fig. 8. The first specimen is of great interest as having been crushed in such a manner as to separate its component elements; while both specimens elucidate for the first time the precise nature of the "rostral plate."

The new specimens demonstrate that Dr. Traquair's determination of the arrangement of the various elements of the shield is correct in every particular; and it is especially interesting to find that in the original of Fig. 7 there is an anterior pair of bones (*p.mx.*), additional to those previously discovered and evidently homologous with the premaxillæ (Traquair) of *Coccosteus*.

The statement that no median bone occurs over the pineal region of *Phlyctænaspis*, made in the Catal. Foss. Fishes Brit. Mus. pt. ii. p. 277, must now be modified; for both the new specimens under

[1] A. S. Woodward, Ann. Mag. Nat. Hist. [6], vol. viii. (1891), p. 8.

consideration show the small pineal plate ("posterior ethmoid" Traquair) fused with the large ethmoid ("anterior ethmoid" Traquair) in front, but separated by a distinct sutural line. Th great pineal pit at the hinder angle of the "rostral" plate thr formed is well indicated in Pl. I. Fig. 8.

Several plates of the body cuirass are also contained in the late collection from Campbellton. There are examples of the lateral an ventrolateral plates (Whiteaves, *loc. cit.* pl. ix. figs. 3, 4); and tw groups of smaller, sparsely tuberculated plates cannot even b provisionally determined. Further discoveries must be awaite before any definite information concerning the disposition of th armature is obtainable.

EXPLANATION OF PLATE I.

Fish-remains from the Lower Devonian of Campbellton, New Brunswick.

Fig. 1. *Protodus Jexi*, sp. nov.; tooth, outer and lateral (1*a*) aspects.
„ 2. *Diplodus problematicus*, sp. nov.; tooth, outer aspect, three times nat. siz
„ 3. *Acanthodes semistriatus*, sp. nov.; fin-spine.
„ 4. *Gyracanthus incurvus*, Traq.; spine, lateral aspect.
„ 5. Ditto; abraded apex of spine, lateral aspect.
„ 6. *Cephalaspis campbelltonensis*, Whiteaves sp.; scale, external aspect, thr times natural size.
„ 7. *Phlyctænaspis acadica*, Whiteaves sp.; head-shield, external aspec *c.* central; *e.* ethmoid; *e.o.* external occipital; *m.* marginal; *m.o.* medi occipital; *p.* pineal; *p.mx.* premaxilla; *p.o.* preorbital; *pt.o.* pos orbital.
„ 8. Ditto; ethmoidal (*e*) and pineal (*p*) plates, visceral aspect.

All the specimens are preserved in the Geological Department of the Britis Museum (Natural History), and, unless otherwise stated, the drawings are of th natural size.

II.—Remarks on Prof. Bonney's paper "On the Crystallin Schists and their Relation to the Mesozoic Rocks in th Lepontine Alps."

By Dr. F. M. Stapff.

I VENTURE to offer some remarks on the above-mentioned pape of Prof. Bonney, which appeared in the Quarterly Journal o the Geological Society for May, 1890 (vol. xlvi. pp. 187–240).[1] A the result of ten years' geological researches in the St. Gothar district, I have become familiar with most of the statements an arguments brought forward by Prof. Bonney; many of them, I a glad to see, agree with my own observations and views, already mad known in official and other publications; others, however, I fee bound to dispute.

I.—*The black schists.*—Prof. Bonney's view that the "*black garne schists*" of the St. Gothard (Nufenen to Lukmanier) are not identi cal with the *belemnitiferous black "spotted" schists* of the Nufene (Bonney, *l.c.* pp. 214, 218, 220, 221) has been held by me sinc

[1] It will, we are sure, gratify our readers to learn that Dr. Stapff, the write of the present article, was the eminent engineer of the St. Gothard tunnel. B accident Prof. Bonney has referred to him in the Quart. Journ. Geol. Soc. 189 vol. xlvi. p. 196, as "the *late* Dr. Stapf" (for Stapf read Stapff). We are glad t be able to state that Dr. Stapff is alive and well.—Edit. Geol. Mag.

1875, and I am glad to find it supported by so high an authority. In a paper I read at the 58th annual meeting of the Schweizerische Naturforschende Gesellschaft, held at Andermatt, September, 1875 (Jahresbericht, 1874–5, pp. 127—156), is the following:—

"Worthy of attention is the frequent association (in the southern section of the Gothard tunnel, 700—800 m. from the mouth) of this calc-mica schist with dark, dense, often phyllitic mica schists which resemble some of the Nufenen 'Knotenschiefer' in having knobs of small garnets. But it should be kept in mind that two different kinds of spotted schists occur in the Nufenen pass. In one of them the knobs are garnets; in the other one cylinders and hail-like grains of a zeolithic[1] mineral, and the belemnites are exclusively found in this last-named variety" (*l.c.* p. 140). Further, the following will be found in the text to "Profil géologique du St. Gothard dans l'axe du grand tunnel établi pendant la construction (1873–1880) par F. M. Stapff, ingénieur-géologue de la Compagnie du St. Gothard" (Annexe spéciale aux rapports du Conseil fédéral Suisse sur la marche de l'entreprise du St. Gothard; Berne, 1881), "The *black schists* of the *Oberalp road* (north side of the Gothard) might be paralleled with certain *black garnet schists of the south side* (Nufenen schists in part.)—Footnote. The belemnites do not appear in the black garnet schists of the Nufenen pass, but in a kind of black schist which much more reminds one of those from Altkirche (likewise on the north side of the Gothard, not far from the Oberalp road). The cylinders in this rock are composed of a zeolitic mineral (comp. *von Fritsch*, p. 127) which probably accounts for the hydraulic qualities which calcined lime exhibits when mixed up with slightly burnt and ground belemnite-schist from the Nufenen. If this parallelization be correct, and the metamorphosed sedimentary rocks of the Ursern valley properly determined, then we may draw the conclusion that the series of the originally sedimentary rocks on the south side of the Gothard begins, at the bottom of the Ticino valley, with *Jurassic* deposits and includes *Carboniferous* at about

[1] I am well aware that these grains and cylinders in the Nufenen schists are usually considered to be *couseranite*; but the existing chemical analyses allow them to be equally as well regarded as f. i. *prehnite*, and this interpretation is not contradicted by Prof. Bonney's microscopic analysis, though the shape of the prisms does not agree with the usual habit and mode of occurrence of prehnite.

Comparative analyses:—

	Mineral in the Nufenen schists.		To be compared with	
SiO^2:	knobs 53·09	prisms 40·07	Prehnite 43·63	Couseranite 52·37
Al^2O^3:	19·45	22·05	24·87	24·02
Fe^2O^3:	5·93	5·66	(6·81—7·38 in some varieties)	—
CaO:	10·95	22·29	27·14	11··5
MgO:	1·03	1·20	—	1·40
H^2O:	6·06	8·89	4·36	KaO,NaO 9·48
Loss	3·49	—	—	—
	100·00	100·16	100·00	99·12

I observed the hydraulic character of the Nufenen schists whilst searching for hydraulic lime in the neighbourhood of Airolo, and made some laboratory tests with them.

1833 m. inside the mountain, counted from the mouth of the tunnel (*loc. cit.* French text, p. 56; German, p. 51, 52). Describing th glacial and alluvial gravels in the Ticino valley ("Geologisch Beobachtungen im Tessinthal, während Tracirung und Baues de Gotthardbahn," Berlin, 1883), I have likewise pointed out th difference between the ordinary black garnet schists and the Nufene 'spotty' schists: whilst the former are spread far down the valley the Nufenen 'spotty' schists were not met with beyond five or si kil. below the pass (*loc. cit.* p. 83).

The fact is, that schists and slates which are coloured by graphit or other coaly material, sometimes phyllitic, sometimes calciferous and often garnet-bearing, occur on the Gothard under various con ditions, and in widely separated geological horizons. On his ma of the Gothard district, *von Fritsch* indicated by the colouration o the Nufenen schist, a patch of *black garnet schist* in the upper par of the Unteralpthal. On examination I found it to be a slende intercalation in the micaceous gneiss of the Sorescia type, which on the summary profile to my geological map of the Gothard railway, is designated by III., and which has been cut by the tunne between 3000 and 4000 m. from the southern entrance. Thi occurrence of black garnet schist in the brown micaceous gneis III. is not an isolated one. I have mapped a quite analogou instance in the upper Val Cadlimo, close by the Lago Scuro.

On a higher horizon, we meet with the *black schists* (withou macroscopic garnets) of the Oberalp road, which were exposed i the tunnel between 3650 and 3800 m. N.; probably they are o *Carboniferous age* and equivalent to the *black garnet schists* on th south side, at 1466 and 1808–1833 m.[1]

Some seams of *black schist* were met with in the tunnel at 326 and 3274 m. N., between the Altkirche schists and the above mentioned Oberalp schists, which have not been traced at the surface; they probably correspond with the *black garnet schists* o the south side at 700–800 m. The bed-rocks are calcareous o *both sides* of the mountain; I consider them to be of *Triassic* age as well as the bulk of the calc-mica schists on the opposite side o the Ticino river, which also inclose several belts of *black garne schists*, one, for example, in the Stalvedro railway tunnel.

Finally we arrive at the highest horizon of *black schists*, viz., those of Altkirche on the north side, met with in the tunnel a 2582, 2637, 2766 m. N., which I consider to be of *Liassic* age and to correspond with the *Nufenen belemnite schists*. These have not been seen in the southern section of the tunnel, though it is possible that they may be represented there by some geological equivalent.

These *different black schists* do not completely agree in their petrographic characters, not even if comparison is made with those which

[1] These and other intercalations of special geological interest have been purposely very prominently marked on the profil géologique in order to attract attention to them. For exact measures and details refer to my record: "Geologische Tabellen und Durchschnitte, über den grossen Gotthardtunnel; Specialbeilage zu den Berichten des Schweizerischen Bundesrathes über den Gang der Gotthardbahn-unternehmung, 1873–1882."

presumptively belong to the same geological age, and at present their presumed horizons are rather guessed at than accurately determined. But the *black schists* which are easily recognized, and in which fossils may be expected to occur, will one day prove valuable criteria for geological classification, and I have therefore indicated them, wherever they occur, not only in the profile of the Gothard tunnel, but also in the "Geologische Uebersichtskarte der Gotthardbahn-strecke Kil. 38–149 (Erstfeld-Castione); 10 Blätter im Maasstab 1:25000; im Auftrag der Direction der Gotthardbahn, 1885." In the title and index-sheet of this map, three distinct designations are given for at least four different sorts of black schists; the colours referring to similar petrographic characters, the letters and numbers to geological position. In this way (which, however, cannot be fully explained without the help of a descriptive text to the map) I have endeavoured to bring the beds together in the order in which they might be expected to succeed each other, without prejudicing the *final* geological grouping, or making the map useless in case some of my views respecting the geological position of some of the beds should subsequently prove erroneous.

II. *The gray mica schists, calc-mica schists, disthene schists.*—I have divided the rocks of the Ticino valley from the mouth of the tunnel inwards to the micaceous gneiss of the Gothard, into the following four groups:

37—90 *m.*;	characteristic rocks:	*dolomites.*
90—1142 m.;	,, ,,	: *gray garnet-mica schists.*
1142—1833 m.;	,, ,,	: *green and black garnet-mica schists.*
1833—3178 m.;	,, ,,	: *felspathic-mica schists and amphibolic rocks.*

Prof. Bonney's "Val Piora schists" belong to the second of these groups (that of the gray garnet schists) and his "Val Tremola schists" to the third and fourth groups (green, black felspathic mica schists and amphibolic rocks). On my geological map of the railway, this whole series is marked by the figures IV. and V. and the *sericite* schists of the Ursern valley are understood to be equivalent to the *gray mica schists* of the south side. (Text to profile, French, p. 47; German, p. 43.)

In the composition of the gray mica schists, two species of mica, at least, take part; of these the gray is the characteristic one. In the text to the profile (German, p. 45; French, p. 49) this is described as "not positively identical with *paragonite*, though containing soda, as shown by blow-pipe tests; potash-mica also occurring in the same schist. When fused to a yellowish white enamel, it becomes intumescent giving a yellow tint to the flame. It has a silky lustre and talcose appearance under the microscope; with a silver-white or grey colour, which often assumes a greenish hue. In the immediate neighbourhood of quartz-veins with copper pyrites, ironspar, cyanite, tourmaline, muscovite, calcspar, etc., this same soda-mica often turns apple-green like that of *pregrattite*; this green colour is of dubious origin (NiO, CuO, Cr^2O^3?), and seems to fade on long exposure to light. The blackish-tint and semi-metallic lustre in the black garnet schists and in many calc schists is due to

graphite; not only is this the case in this group of the mica-schist series (700—800 m.), but also in the following (green schists at 1318, 1466, 1808, 1828 m., etc.) and in the black schists of the north side. Garnets are seldom absent, but in the schists close to the dolomites they are small, rare, and sometimes scarcely visible. The second constituent mica is brown magnesian; it is in part original, in part a pseudomorph, after hornblende.

Disthene, cyanite, staurolite (rarely, for example, at 632 and 753 m.) occur in certain beds throughout the gray mica schists, whilst they are but sporadic or microscopic rarities in the succeeding green amphibolic and felspathic mica schists. Real staurolite schists comparable with the typical beds of Alpe Sponda have not been met with in the tunnel (text to profile, French, p. 50; German, p. 46) and large radiant prisms of disthene are commonly connected with quartz veins (180, 190, 397 m.), which at the same time carry copper pyrites, pyrrhotine, ironspar and tourmaline (rare). The beds in which disthene and kindred minerals can be recognized at a glance, *e.g.* at 190, 397, 536, 606, 632, 732, 792, 808, 854, 868, 912, 1119 mètres from the mouth, are usually connected with the calc-mica schists and black garnet schists; but it would be premature to assert that certain geological horizons in the gray mica schists are characterized by the appearance of disthene, etc.

The complex of gray mica schists containing garnets, disthene staurolite (tourmaline), appears again *on the opposite side of the Ticino valley* (up in the mountains), whence it enters Val Chironico, with the renowned Sponda Alp; and it may be seen from the geological map of the railway, plates vi. vii., that even here these mica schists are underlaid by micaceous gneiss and overlaid by real calc-mica schists, with intercalations of black schists, quartzites, and (last but not least) by dolomites, rauchwacke, marble, etc., in repeated beds.

The so-called *calc-mica schists* of the Gothard tunnel (south side, text to profile, French, p. 50; German, p. 45) differ to some extent from the calc-mica schists on the opposite side of the Ticino valley; the calcspar being scarce and often absent in the rusty outcrops of the small seams; which are then hardly recognizable as continuations of the corresponding calcareous mica schists in the tunnel (pl. v. of the geological map along the railway line). The calcspar usually occurs together with quartz or felspar, in thin crumpled, broken and faulted lamellæ, which by the decomposition of pyrites or carbonate of iron are often rusty and carious. Some quartzitic beds of this mica schist series and some amphibolites (*hemithrènes*) also yield grains and lamellæ of calcspar, and it would be interesting if there were means of distinguishing the original constituent from the secondary calcspar, so as to be able to decide whether these intercalated seams are real or pseudo calc-mica schists. With regard to their designation in the profile of the tunnel, I refer to the remarks made above respecting the black garnet schists.

Certain seams of the sericitic schists of the Ursern valley (north side) are also calcareous (3255–85; 3560–70; 3650, 3666 m. N.,

German text to profile, p. 22; French, p. 24) and thus comparable with the described calc-mica schists of the south side. Macroscopic garnets, disthene, etc., are lacking on the north side, where *anhydrite*,[1] *gypsum*, and gunpowder-like *magnetic iron* are interesting accessory constituents of the calcareous sericite schists; and the presence of *rolled grains of quartz* prove them to be originally psammitic rocks.

It should, moreover, be kept in mind that sporadic intercalations of calcspar are by no means rare in the crystalline schists of the St. Gothard. They frequently occur in the green felspathic and amphibolitic schists of the south side; in the black schists of the Oberalp road on the north side; sometimes also in the micaceous gneiss of the Gothard massif. Intercalations of limestone always point to an original sedimentary formation of the surrounding schist. A direct proof of this is the existence of *rolled gravels* in the amphibolic mica schist at 396 m. S. (text to profile, French, p. 52; German, p. 48. Geolog. Durchsch., Südseite, Nos. 55, 56); of *rolled quartz grains* in the sericitic schist (text to profile, French, p. 25; German, p. 20. Geolog. Durchsch., Nordseite, No. 64, 68, 69, 72, 74, 76, p. 83), and of *psammitic quartz rock* (talc quartzite; verrucano?) between the beds of black schist at 3733, 70, 80, 94 m. N.

The calc-mica schist at the mouth of the Moësa, in the Ticino (pl. x. geol. map along railway), is in a greatly advanced condition of metamorphism, but though changed into calcareous gneiss with accessory disthene, garnets, actinolite, and titanite, and including beds of marble and cipoline, it must be considered as the equivalent of the calc-mica schists of Airolo (tunnel), and of the mica-schist with imbedded calcareous rocks of the Jorio pass (summary profile of the railway on title sheet of the map).

Continuing the parallelization of the schists on the south side of the St. Gothard with those on its north side, we have to place against the *green garnet-mica schists* with their intercalations of *black garnet schists, calc-mica schists,* and *quartzites*, the *black schists of the Oberalp road* with their belongings, and against the *felspathic mica schists* and *amphibolic rocks* of the Scipsius (IV. in the scheme on title plate of the map) the slaty gneiss of the north side for which I have proposed the name *Ursern-gneiss* (see sub-section V.).

An analogous rock, with striking intercalations of *hälleflinta*, is passed by the railway line near Gurtnellen on the northern flank of the granitic gneiss belonging to the Finsteraarhorn massif (Geol. Map, pl. iii. and title sheet), and southwards from Airolo a corresponding gneiss underlies the gray mica schists below Passo Sassella (pl. vi.), and between Monte Piottino (Daziogrande) and *Monte Olina* (Val Chironico). But amphibolic rocks, which abound near Airolo, are rare or altogether absent in the other localities (Ursern valley, Gurtnellen, Val Chironico).

III. *Dolomite, rauchwacke, marble, cipoline, and subordinate rocks.*—The detailed section between 37 and 90 mètres from the southern entrance of the tunnel, shown on a scale of 1:200 on plate i. of the

[1] Zeitsch. d. deutsch. geol. Gesellsch, 1879, p. 407.

Geol. Durchschnitte, Südseite, is highly instructive for the interpretation of the rather irregular or lenticular masses of rauchwacke which figure on the geological maps of the country. The same rock which, in the ragged cliffs N.E. and S.W. of the tunnel appears almost homogeneous (though greatly decayed), is, in the tunnel, unrolled in a long series of alternating concordant strata of *rauchwacke, saccharoidal dolomite, marble, breccia, 'ash,' quartzite* and *mica schist*, this last named forming not only some well-defined beds at the end of the series, but also thin separating sheets between the different calcareous layers, and patches in their mass. I am not convinced that these fragments are, in all cases, the detritus of pre-existing mica schist inclosed in the lime rock; sometimes the white, gray, or greenish coatings of talcose mica appear to have been formed contemporaneously with the calcareous material or even subsequently; in other instances they are certainly torn and crushed fragments of the intercalated mica schist which have been squeezed into the dolomite by mechanical forces. Prof. Bonney lays stress upon the occurrence in the dolomites, etc., of fragments of mica schist, which indicate their psammitic nature. With the reservation just mentioned, I share this view, which I have already published in the "Geol. Durchschnitte und Tabellen, Südseite," specially with reference to No. 10 ("dolomitic ash," a dirty greenish medley of dolomite, talc, etc.) and to No. 14 ("breccia" at 78·5 m., which is thus described, "Yellowish, ashy, cavernous rauchwacke, inclosing sharp-edged fragments of talcose mica schist and of saccharoidal dolomite, with white or rusty saccharoidal or sandy dolomite in the cavities. This bed, so far as it is not a vein, *proves that the dolomitic strata are younger than the mica schist on their hanging wall*"). Very similar remarks are made in the text to the Geological profile (German, p. 44; French, p. 48, and in "Verhandl. der Schweiz. Naturf. Gesellsch." 1874–75, p. 139): "the occurrence of this mica-dolomite breccia seems to prove that the dolomites are younger than the surrounding mica schists."

Dolomitic material is predominant in the chequered line of thin strata in this section of the tunnel, which have together been subjected in common to contortion, faulting and squeezing, so that it is difficult to understand why the same mechanical forces should not have exercised similar metamorphic effects on every individual bed of the whole series, which they are believed to have exercised on *some* of them; why, for example, mechanical "marmorization" has taken place in No. 17 at 82·3—83 m.; but not in the preceding bed of white loose saccharoidal dolomite, nor in the following one of white and red dolomitic bands which alternate with strings of quartz and mica-schist? How are we to explain the alternation of beds of rauchwacke with saccharoidal limestone if the transformation of one of these substances into the other were due to pressure which has acted through the whole complex? Leaving on one side the formation of breccias, it does not seem probable that petrographic metamorphosis by mechanical forces has played an important rôle in our case; I am inclined to consider that the chemical or physical

constitution of the different beds was originally dissimilar, so that the course and the results of any metamorphic action would necessarily have varied in different parts of the whole complex. Further, it is not necessary to assume that any *chemical* metamorphosis must have embraced an entire complex of calcareous or dolomitic strata; it might equally as well have been restricted to certain regions, (marked off by stratification, fissure, or other lines) thus producing heterogeneous mass-shaped intercalated deposits, such as for instance *gypsum* and *anhydrite* imbedded in rauchwacke. As a matter of course, these irregular intercalations are not then of marked value as geological horizons. At the Airolo mouth of the tunnel, *gypsum* or *anhydrite* only appeared as accessories in the quartzite beds, No. 20 and 22, belonging to the dolomitic series, and in fissures in the adjoining rocks. In the calcareous rocks of the Ursern Valley, the occurrence of gypsum was restricted to lumps of alabaster imbedded in the clayey southern wall-rock.

Having regard to the petrographic variety in rocks belonging to one and the same calcareous series, it seems hazardous to ascribe, *à priori*, a definite geological age to such rocks when they are met with isolated. For this reason I have indicated on the geological map of the railway line, by a single colour, all limestones ranging between the Jurassic and Archæan, noting by index letters their special petrographic characters (dolomite=D.; rauchwacke=R.; marble=M.; cipoline=C.; calc-schist=Cas.), and leaving the question of their exact geological range to future exploration. I have paralleled the limestone series of the Ursern valley, which is considered to be *Jurassic*, with the dolomitic series of the south side, in spite of considerable petrographic differences—rauchwacke and saccharoidal dolomites are, for instance, wanting in the tunnel below the Ursern valley, whilst cipoline predominates there, though absent on the south side, etc. The appearance of quartzitic beds in the foot-wall of the Jurassic (Liassic) rocks affords a means of identifying them on both sides of the St. Gothard. It has already been remarked in "Verhandl. der Schweizer Naturfor. Gesellsch." 1874–75, p. 139, and in the text to the "Geol. Profile" (French, p. 47; German, p. 43) that beds of quartzite (resp. sandstone) are regularly associated with the limestone series north and south; they occur, for instance, at the Nufenen pass (à la Cruina), in the tunnel, near Lago Ritom, near Prato, and, on the other side, on the Längisgrat, Furka, near Realp, and Altkirche.

The description given by Prof. Bonney on p. 210 of his paper of a section along a ravine in Val Canaria agrees in its principal features with my own surveys in the same ravine and the adjacent areas, which have been used for the construction of plate v. of the geological map of the railway; and on principle I cannot object to this author's explanation of repeated identical beds (rauchwacke, in this case) by faults instead of by folding, though I have based the construction of this part of the map on the supposition of folds. The construction of ideal folds on ideal sections means for me nothing but a way of indicating the supposed identity of certain beds, of which only the

outcrops are known, and nothing more. From the same point o view I also constructed (on the profile of the line of the tunnel) two troughs and an intervening saddle in the Ursern valley, re marking (French text, p. 28; German, p. 26), "The saddles and troughs drawn indicate no more than *une manière de représenter* the course of the beds in the Ursern valley." The same remarks are applicable to the general section on plate vi. of the geological map which represents an ideal connexion of repeated seams of dolomite calc-schists, and black and gray mica schists, between Val Piora (Lago Cadagno) and Campolungo. I wish to say, that I am no now satisfied with that profile, as it was not necessary to compress the three or four beds between the Ticino valley and Campolungo in a complicated system of folds, since they can quite as well be representatives of different horizons of a couple of beds repeated by faulting.

It must be admitted that the probability of faulting is, *à priori*, greater than that of folding; this agrees with the mechanical conditions of contraction as explained by the Rev. O. Fisher in his "Physics of the Earth's Crust," and a most demonstrative example of this same view is shown in that part of the profile of the Gothard tunnel which represents the central part of the massif. The upheaval of the mountain, the swelling, uplifting and overthrow of the strata, are not so much due to wave-like folding of the crust, as to its crushing and to the shoving and squeezing of the flakes over and through one another.

IV. *Organic remains in the Calcareous beds of the St. Gothard.*—Though I have not succeeded in finding *crinoids* at every spot in the Ursern valley indicated on the geological map of *von Fritsch*, there is no doubt of the existence of imperfect fragments of these organisms in those and other places in the calcareous series of the valley (see pl. iii. of the geological map of the railway line). Cylindrical or elliptical sections of stems of crinoids or spines of echinoderms, have been observed also in the tunnel; for example, in the gray cipoline, No. 43, at 2593 m., and in the black schist, No. 46, at 2637 m., and in this latter undetermined *fucoids* were also present. In addition to these, microscopic globules of coaly matter and peculiar rod-like pyritic bodies, which in section resemble some forms of *foraminifera*, have been noticed (black schist, No. 42, at 2582 m.). Some laminæ of calcspar intersecting the crystalline limestones and cipoline, were not infrequently covered with a network of graphite (or other coaly material) so as to resemble organic forms, but they are not organic, and have never been represented as such by me (Geol. Durchsch. u. Tabellen, Nordseite, p. 54–59; text to geol. profile, French, p. 23, 24; German, p. 21, 22).

Only after a thorough examination of 26 slides taken from different beds of the calcareous series between 2582 m. and 2783 m. N. did I discover in two of them (No. 43 at 2593 m. and No. 45 at 2682 m.) traces of microscopic organic fragments,[1] which I have

[1] Faint traces of structures, resembling those on No. 43, have also been lately noticed in a section of No. 47.

referred to in the "Zeitsch. d. deutsch. geol. Gesell." 1878, p. 138, as follows: "Only in Nos. 43 and 45 have those puzzling microscopic structures been noticed, of which I sent a drawing to Prof. Desor, 26th Feb. 1877, and to which I drew the attention of Prof. Zirkel by letter of 29th Oct. 1877. In the text to the geological profile (German, p. 22; French, p. 24) they are described as blackish indistinct points (pores) arranged in rows, so as to form four-rayed stars by their intersection at right angles to each other. Professor Gümbel, who examined my slides, declared them to be unequivocally structures of crinoids, and this accords with the occurrence of circular or elliptic sections of crinoid stems in the cipolines, both inside and outside the tunnel (Ruestli; heap E. from Altkirche). The woolly threads of graphite in No. 45 are partly grouped in polymorphous net-works, one of which I have copied in Zeitsch. d. deutsch. geol. Gesellsch. vol. xxx. 1878, p. 138. No palæontologist who has seen this slide has doubted the organic nature of the form contained in it; but the interpretations of its character have varied between corals, sponges, and bryozoa—Prof. J. Hall inclines to this latter view of their origin.

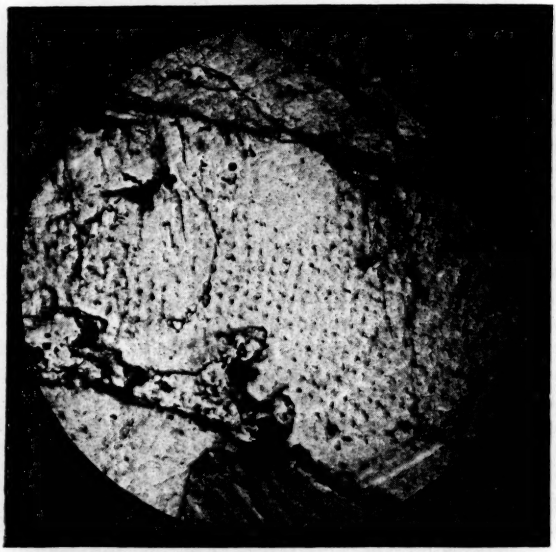
I believed the question of the organic character of the fragments in this highly crystalline micaceous limestone to have been settled; but finding that Prof. Bonney (*loc. cit.* p. 198, footnote) declared them anew to be *pseudo*-organic, I submitted the slides to Professor Möbius, Director of the Royal Museum at Berlin, so well known for his investigations on the structure of Eozoon, and he has given me permission to state that "*these forms in his opinion are of organic nature*, so far as can be judged from a hasty examination of only *two* slides, without comparing them with analogous structures." I have lately had taken microscopic photographs of the structures in the slides referred to, Nos. 43, 45, and the accompanying figures have been reproduced from them by autotypic process (see p. 16).

With regard to No. 45, I may remark that the light gray cross lines of the net-work seem in part to follow the cleavage faces through the calcspar, and would thus agree with Prof. Bonney's description of crinoidal microstructure in preparations from Scopi (*loc. cit.* p. 234–35). If No. 45 should beget any scruples as to its real nature, they would not affect No. 43, in which the black points and blisters are arranged in slightly curved lines, which intersect one another at angles of about 80° and 100°.

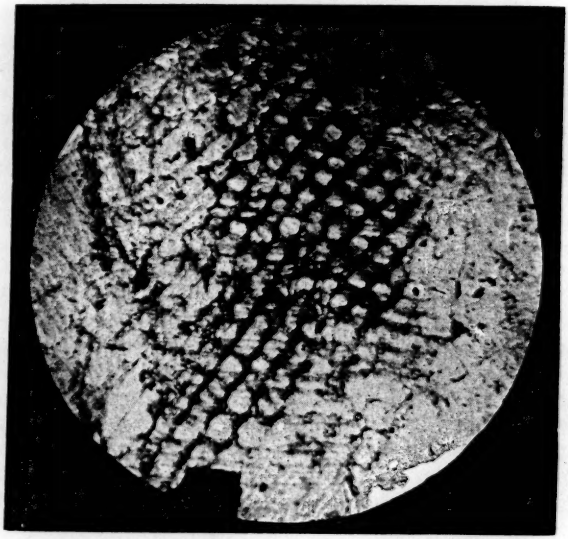
Though these microscopic traces of organisms in the Altkirche cipolines indicate the existence of crinoids, which were already known macroscopically and are without special value for the fixation of geological horizons, yet they are of great general interest as showing how the structure of fragmentary Jurassic fossils can be preserved in highly metamorphic micaceous limestone. It is now fourteen years since they were first noticed.

V. *Classification of the crystalline schists in the St. Gothard (and their relation to the Mesozoic rocks).*—The first arrangement of the beds passed through in the St. Gothard tunnel, which I sketched in the "Neues Jahrbuch für Mineralogie, etc.," 1878, has since re-

From Bed No. 43.



From Bed No. 45.



Microscopic Sections of Micaceous Limestone from the St. Gothard Tunnel.

EXPLANATION OF AUTOTYPE FIGURES ON PAGE 16.

Microscopic sections of micaceous limestone from the St. Gothard tunnel, showing traces of organic structures. Reproduced by Autotypic process. Enlarged to the scale of 180 diameters. The upper one is from Bed No. 43; the lower from Bed No. 45.[1]

mained the groundwork for the subsequent classifications published in the geological profile of the tunnel (1880), and in the title sheet of the geological map along the railway line (1885). The summary profile between the Lake of the four Cantons and that of Lugano, as there delineated on the scale of 1 : 250,000, affords an insight into the structure of the Lepontine Alps which differs materially from others drawn up before the construction of the tunnel. Space would not permit me to give detailed references to this profile, and I shall therefore restrict myself to a sketch of the classification of the crystalline schists for which I wish to maintain my priority.

1. The *micaceous gneiss* with predominant magnesian-mica, which in the central part of the Gothard massif occupies the Guspis valley between Greno di Prosa (dividing ridge of the St. Gothard) and Alpetligrat, and extends in the tunnel for a distance of 2270 mètres, from 5450 m. S. to 7200 m. N., is the oldest or deepest of the crystalline schists of the St. Gothard, and as such is marked by *I*; *Guspis glimmergneiss.* One peculiarity of the same beds is the occurrence of black *tourmaline* together with garnets. Gneissic, micaceous, amphibolic, and quartzitic varieties, exist in it, as well as in the succeeding groups, and they have been carefully set out in the Geol. Durchsch. (1:200), and summarily in the profile of the tunnel, not only for engineering purposes, but also to serve as marks for the identification of crystalline strata on either side of the mountain.

The presence of *rolled* quartz grains (*sand*) in some beds of the Guspis micaceous gneiss, which have been duly noted in the Geol. Durchsch. (for instance No. 130 N. at 7262 m. p. 178, 9), and in the text to the geol. profile (German, pp. 28, 31, 36; French, pp. 31, 34, 39), proves beyond doubt the original sedimentary character of this gneiss, and this view is corroborated by the occurrence of occasional small bands of limestone (at 6100—6110, 7352 N.), frequently containing microscopic globules of graphite or other coaly material.[2] As a consequence, all the succeeding crystalline schists of the St. Gothard must also be considered to be metamorphosed sediments, so far as they cannot be shown to be of plutonic origin.

2. The *Sellagneiss*, southwards of the micaceous Guspis-gneiss and the Gamsboden-gneiss (a term introduced by *v. Fritsch*) northwards of it, occupy the second horizon of the crystalline schists, which is marked by *II*. I consider them equivalent to the Ticino gneiss south of the St. Gothard, which is crossed by the railway line between Daziogrande and Claro, and noted on pls. vi.—x. of the map

[1] As already mentioned by Prof. Bonney (*loc. cit.* p. 198) hand-specimens of these St. Gothard rocks are preserved in the Mineralogical Collection of the British Museum (Natural History), and sections, taken from the one marked No. 43, show precisely similar structures to those in the accompanying figure.—EDIT. GEOL. MAG.

[2] There is no question here about graphitic mirrors on fissures.

as Piottino[1] and Tessiner gneiss; and also equivalent to the gneiss
the neighbourhood of Erstfeld, north of St. Gothard (pl. i. of map
In the tunnel this gneiss with its varieties and occasional intercal
tions of micaceous and amphibolic rocks, occupy about 1000 mètr
(4000—5000) on the south side, and 1400 m. (6000—7400) on th
north side, but it should be observed that frequent repetitions an
transitions of the terminal beds tend to make these limits rath
elastic. The *Sella gneiss II.* is a highly crystalline felspathic roc
containing both potash- and magnesian-mica, and it has a vein
uneven or lamellar, glandular structure.

3. The Sella gneiss is succeeded by the *micaceous gneiss II*
named after the *Alpe Sorescia* on the south side, and after th
Gurschen Alp on the northern side. It occupies in the tunn
800 m. (3200–4000) on the south, and 1700 m. (4300–6000) on th
north side. The predominant mica is brown or grey magnesian
that of the north side often assumes a green colour, and from th
and from the occurrence of sericite it passes over into Ursern gneis
whilst accessory garnets and hornblende in its boundary beds on th
south side indicate a relation to the felspathic mica schist of th
Scipsius. Moreover the rocks of this series have more frequent
the character of mica schist than of gneiss.

The gneissic series *III.* is better characterized from a geologic
than from a petrographic standpoint. The peridotic and pyroxen
serpentines of the St. Gothard make their appearance in it, as al
certain of the *black garnet schists* and some insignificant o
deposits. The *serpentines* which crop out along the Ursern valle
between the Unteralpthal, Gige, Hospenthal, and Zumdorf (pls. i
and iv. of geol. map) were passed in the tunnel between 4870 an
5310 m. N.; and an analogous series of lenses of serpentine h
been followed on the south side, in the same micaceous gneiss,
both slopes of the Val Tremola, near Seara Orell and Fieudo (pl.
of geol. map), though not met with in the tunnel. Beyond th
northern slope of the St. Gothard on the other side of the granit
Finsteraarhorn gneiss. *diallagic* (?) *rock* appears near Gurtnellen an
down on the railway line near Meitschlingen in the same series II
(or IV.?). Finally, we find *serpentine* south of the Gothard in th
neighbourhood of Bellinzona, at Castanetta, E. of the railway, an
at Sementina W. of it—in both cases in micaceous gneiss belongin
to III., which also is the prevailing rock of Mount Ceneri and in th
Agno valley downwards to Gravesano and Manno, where it mee
the Palæozoic rocks. (Profile on title-sheet of map.) The *bla*
garnet schists of the Unteralpthal and Val Cadlimo (Lagoscuro), whi
are imbedded in the micaceous gneiss III. have been mention

[1] "Piottino gneiss" means the uppermost beds which on Mount Piottino (Daz
grande) dip under the mica schist formation. Tessiner gneiss is an old term
Studer's, which refers to the nearly horizontal strata of gneiss along the Ticin
Near the railway station Claro they abruptly assume a sharp southward dip, a
are then overlaid by a newer gneiss formation (See pls. ix. and x. of the map a
Explanation of the same in Zeits. d. deutsch. geol. Gesells. 1884, vol. xxxvi., a
Neues Jahrb. f. Mineral., 1882, vol. i. p. 72, where also the relation between t
parallel structure and the stratification of the Piottino gneiss is treated of.

under § I. Insignificant amounts of *zincblende*, *galena*, and *pyrites* have been found in the same gneiss, not only at the surface (mining trials in Val Cadlimo), but also in the tunnel at 3250–70, 3376, 3955 m. S., and at 4410 m. N. The zincblende formerly found near Hospenthal ("im Saum") and, together with mispickel, in the Tiefthal near Meitschlingen, on the north side of the Gothard, may also appertain to the same micaceous gneiss, as also that near St. Nazaro on the Lago Maggiore, where some small adits have been commenced in former times.

4. The fourth group of crystalline schists, comprising transition rocks between the gneiss-formation and the mica-schist formation, has already been mentioned in connexion with the last named (§ *II.*). The *Ursern gneiss* of the north side, and the *felspathic mica schists of the Scipsius* (south side) were passed in the tunnel between 2000—4300 m. N. and 1850—3200 m. S. respectively; the former enveloping the troughs of the Altkirche limestones and of the sericitic schists with the black schists of the Oberalp road. The appearance of slaty gneiss or felspathic mica schist northward and southward from the St. Gothard at Gurtnellen (probably also near Amsteg), in the Ticino valley south and west from Faido, between the Moësa and Bellinzona, at the foot of Mount Ceneri is recorded on plates ii. vi. viii. x. and on the summary profile of the geological map. Whilst the Ursern gneiss north of the Altkirche limestones is a genuine slaty felspar-gneiss, it has, south thereof, more relation with mica schist. Sericitic mica (besides the magnesian) and intercalations of quartzitic and gray-green micaceous beds indicate an analogy between these rocks on both sides of the limestones; but I should not be opposed to a separation of the same, if the deciphering of the geological structure of the Ursern valley would thereby be promoted. The felspathic mica schist of the Scipsius (south side) differs from the Ursern gneiss in containing abundantly beds of amphibolite; on the other hand, green micaceous and calcareous strata *are common* to the Scipsius schists and to the micaceous Ursern gneiss near its boundary with the Gothard massif.

In the summary profile I have made an attempt to parallel these groups of crystalline schists with the previous classifications of *Favre*, *von Hauer*, and *Gastaldi*, without being convinced that such a parallelization is practicable in detail; and a further attempt to fit these different crystalline schists into the frame of the American classification of the Archæan, I now recognize to be a mistake, since the Gothard rocks, from I. upwards, are decidedly *younger* than Archæan.

5. The rocks belonging to the fifth series, viz. gray and green mica schists, with or without garnets and disthene, sericite schists, black schists, calc schists, dolomites, cipoline, marble, rauchwacke, have been characterized in § I.–III., where it is pointed out that they extend from the Carboniferous to the Jurassic age. They occupy the trough of the Ticino on the south side, and on the north side that of the Ursern (pls. v.–vii. and iii.–iv. of the map; summary profile on title sheet); but they are represented also north of the Gothard,

between Gurtnellen and Amsteg (pl. ii.), and south of it in the Jo pass, E. of the railway line; and the calcareous gneiss near Castio with imbedded seams of marble (pl. x.), probably belongs he though it is in a more advanced state of metamorphism.

O. The Ursern gneiss IV. is broken through by the *granitic gne* belonging to the *Finsteraarhorn massif*, over which the railway li runs from Göschenen to Gurtnellen (pls. ii. iii.). It differs fr the gneiss of the St. Gothard and Ticino valley, not only by its co pact structure, and the peculiar habitus of the quartz and felspa but also by the predominant iron-magnesian-mica on the side pellicular potash mica. I have marked it on the summary profile O°, thus indicating that it belongs to a series distinct from I.–I It is not eruptive or plutonic in the ordinary sense of the words, b it belongs rather to an horizon deeper than the lowest (I.) open in the tunnel, and if thrust up in a solid state, it must consequent have been *after* the Gothard series, either in immediate connexi with the general disruption of the mountain or during subseque paroxysms. Granulitic contact rock limits the granitic gneiss on northern and southern boundaries (pls. ii.–iii.).

Eruptive rocks ?—In connexion with the upthrusted but n eruptive granitic gneiss of the Finsteraarhorn massif, we have final to consider two rocks of the St. Gothard which *seem* to be *intrusi* viz., the *serpentines* and the *granite*. The peridotic *serpentines* alrea mentioned as embedded in the micaceous gneiss III. have been d scribed petrographically in the Geol. Durchs. u. Tabellen, Nordsei p. 114–123, and in the text to the geol. profile, German, p. 3 French, p. 38. With regard to their mode of occurrence so diagrams are given in "Materialen für das Gotthard profil; Verhan der Schweiz. Naturf. Gesellsch., 1878." In spite of the seemi discordance between the serpentine and the surrounding micaceo gneiss, which is very plainly seen in the figures of the treatis quoted above, I believe that the serpentine originally formed lenticul beds in the sedimentary series of crystalline schists, which in t process of general destruction have been severed in pieces a together with the wall-rock thrust along on the fissures. Wherev such a faulted fissure forms the local boundary between serpenti and micaceous gneiss, the former appears to penetrate the latter.

Granite.—A belt of granite extends eastwards from the Piz Rotondo on the north side of the Ticino valley, and disappears, aft passing the Val Tremola, without reaching the line of the tunn (pl. V.). It is a typical granite which does not belong to the S Gothard series of crystalline schists; it has a compact granitic stru ture, and is distinguished by the light rose colour of its quartz. C the Alpe Fieudo (below the Fibbia), in Val Tremola, and near t Sella bridge (below the hospice), direct contacts between this grani and the micaceous gneiss (III.) show its intrusive character (sket on pl. V. of geol. map. along the railway line), but stepping over t granite from its point of contact south of the Sella bridge, towar the Hospice, one observes a gradual transition into the so-call Gothard granite (Fibbia gneiss), or what I have designated as Sel

gneiss (II.). Here the relation between the granite and gneiss becomes rather puzzling; I have shown its details in a profile (1 : 10,000) on pl. V. of the map, and described them in a paper ("Ueber das Verhältniss des Granits zum Gneiss am Gotthard") read at the 55th meeting of Deutsche Naturforscher u. Aerzte, held at Eisenach, 1882.

Weissensee, Berlin, 7 *Oct.*, 1891.

III.—The Fauna of the Olenellus Zone in Wales.

By Henry Hicks, M.D., F.R.S., Sec.G.S.

In his recently published excellent Memoir on the "Fauna of the Lower Cambrian or Olenellus Zone,"[1] Mr. Walcott has referred briefly to the presence of the fauna in Wales. The following additional facts bearing on the question may therefore be of some interest, and they will, I think, show that there is strong evidence in favour of the conclusion arrived at, that the Olenellus fauna occurs in the Caerfai Group of St. Davids, and in beds at the same horizon in North Wales.

South Wales.

In the year 1871, in a paper printed in the Q.J.G.S. vol. xxvii. p. 399, I described and figured some fossils which I had discovered near the base of the Lower Cambrian Rocks at St. David's. They were *Lingulella primæva*, *Discina pileolus*?, *Leperditia*? *Cambrensis*, and "part of the head of a Trilobite from a bed at the base of the purple rocks about 3000 feet below the Menevian Group" (*i.e.* in the beds immediately following the basal Cambrian Conglomerate, which rests unconformably on the Pre-Cambrian rocks). The Trilobite (head) (fig. 18, pl. xv.) was too indistinct for identification, and I refer to it now mainly to note the interesting fact that a Trilobite had been discovered at that time at the very base of the Cambrian at St. David's. What, however, has proved since to be of more importance was the discovery, about the same time, in a highly cleaved red slate near the same horizon, of several small fragments which I recognized to be portions of a Crustacean, but which I then incorrectly associated under one name in my description of *Leperditia*? *Cambrensis*. These fragments and others I have since obtained have now satisfied me that they are portions of heads of a species of *Olenellus*. In referring to them I said that some of the specimens "show a reticulated ornamentation." This form of ornamentation of the surface has now been shown by Professor Schmidt.[2] Mr. Walcott, and others to be characteristic of *Olenellus*. I am hoping that, ere long, another zone may be discovered, in beds which have suffered less from cleavage, and that it might be possible to give specific identifications, but at present it is only possible to say that the genus does occur there,

[1] Extract from the Tenth Annual Report of the Director of the U.S. Geological Survey, Washington, 1890.

[2] "Ueber eine Neuentdeckte Untercambrische Fauna in Estland," St. Pétersbourg, 1888.

and that the horizon of the fauna is very near the base of the seri
As this fauna is separated by about 1000 feet of red and purp
sandstones and slates from the next overlying fauna (*Pluton*
Sedgwickii and *Conocoryphe Lyellii* zone), it is quite possible th
other zones, containing different species, may occur between, for
the higher beds containing *Paradoxides* each important zone
characterized by a new species. In the Cambrian succession at S
David's the most marked changes in the sediments occur almo
immediately below the *Plutonia* beds, and at the top of the Menevia
but the greatest palæontological break is undoubtedly at the close
the Menevian. This tempted me in former papers to divide th
Cambrian at St. David's into an Upper and a Lower division onl
but as, at present, there seems to be a desire to make a threefol
division, there can be no serious objection to restricting the tern
Lower Cambrian to the Caerfai Group (*Olenellus* fauna), Midd
Cambrian to the Solva and Menevian Groups (*Paradoxides* faun
and Upper Cambrian to the Maentwrog, Ffestiniog, Dolgelly an
Tremadoc Groups. I may here mention that the sandstones at th
top of the Menevian, which yielded *Orthis Hicksii* and other Brachi
pods, are now known to contain a *Paradoxides*, probably a ne
species, and a new species of *Conocoryphe* (which I hope to descril
shortly). This somewhat extends the range upwards of *Paradoxide*
but the genus is still confined within the limit of the Menevia
Group.

North Wales.

After referring to the fossils found in the Lower Cambrian rock
of St. David's, Mr. Walcott says (p. 580): "These, with the specie
from North Wales, described by Dr. Henry Woodward[1] as *Con*
coryphe viola, do not prove the presence of the *Olenellus* zone; bu
the weight of stratigraphic evidence is so strongly in favour
including them in its fauna that I shall do so. In the summer
1888 I visited the locality of *Conocoryphe viola*, and found fragment
of it associated with a species of *Hyolithes*." Mr. Walcott's vis
was made during the excursion of the International Geologica
Congress, which I conducted to the Penrhyn Slate Quarries, in 188
The position of this fossil is given in the "Explication de
Excursions," p. 38, as near the horizon of the *Plutonia* and *Con*
coryphe Lyellii zone at St. David's; but it is quite possible that
might be somewhat lower than that horizon, though evidently highe
than the *Lingulella primæva* zone. Most of the red and purple slate
occur below the *C. viola* zone, and there are evidences of fossils i
these beds. The succession in the Cambrian rocks at Penrhyn
Llanberis and in the Harlech Mountains, so nearly resembles tha
at St. David's that it has been possible to indicate the position i
those areas of all the main zones found at St. David's, and at presen
it only remains for them to be worked out.

The following section contains the chief fossiliferous zones whic
are now known to occur in the Cambrian rocks of Wales, and b
its side I place a section which was given for Wales in my pape

[1] Quart. Journ. Geol. Soc. vol. xliv. p. 74.

Chief fossiliferous zones now (1891) known to occur in the Cambrian rocks of Wales, compared with those known in 1875.

"On the Physical Conditions under which the Cambrian and Lowe Silurian Rocks were probably deposited over the European Area, in the Q.J.G.S. for 1875, which has been reproduced by Mr. Walcott along with the map and sections for other European areas, in hi monograph. The main lines of division and zones remain as give in that section, but it has since been possible to make several im portant sub-divisions and to add new zones.[1]

The information obtained since the Map was published has con firmed the view I expressed in the paper that wherever the base lin of the Cambrian is seen throughout the European area, it is almos invariably found to "rest unconformably upon an earlier series o rocks," and that the beds varied in thickness and character in ac cordance with the unevenness of the old pre-Cambrian floor and along fairly well-marked lines of depression. It is not, of course, t be expected that there should be an unconformable break betwee the Cambrian and Pre-Cambrian in all parts over a very large area and Mr. Walcott shows that there is conformity at that horizon i several districts in America. In future the faunas must determine the position where there is any doubt as to the presence of a physical break. In Britain fortunately there is evidence of a very marked break at the base of the Cambrian in all the areas examined.

IV.—Reade's Theory of Mountain-Building.

By A. J. Jukes-Browne, B.A., F.G.S.

MR. MELLARD READE'S book on the "Origin of Mountain Ranges" has now been before the geological public for five years; it has been reviewed in this Magazine and elsewhere, and several more or less weighty objections to the theory have been put forward; but no very complete examination of it has been attempted. This may be partly due to the manner in which Mr. Reade has presented his theory, for he has certainly been too diffuse over points which require very slight illustration and not nearly explanatory enough on other points of great physical difficulty.

Having had occasion to pay some attention to the subject, it has seemed to me that some of the difficulties raised by some of his critics are not so great as they imagine, while there are other difficulties which neither Mr. Reade nor his critics have sufficiently considered. It may seem rather presumptuous on my part to enter a field of controversy where such men as O. Fisher, C. Davison, and M. Reade, are the debaters, and where the chief weapons used —physics and mechanics—are such as I have small acquaintance with. But some of the questions dealt with can be handled without more than an elementary knowledge of these subjects, and I fancy there are many geologists who wish to know exactly how far Mr. Reade's theory can be accepted as a *vera causa*. In what follows, therefore, I am only endeavouring to assist in forming a conclusion on this point.

[1] See "The Classification of the Eozoic and Lower Palæozoic Rocks," Popular Sci. Rev. 1881, and "Recent Researches among Lower Palæozoic Rocks," Proceed. Geol. Assoc. vol. vii.

In the first place I will deal with three objections which seem to me to be capable of being partially answered:

1. Mr. Fisher, reviewing the book in this MAGAZINE,[1] criticizes Mr. Reade's conception of the physical state of the material below the crust: the wording of the passage quoted from Mr. Reade's book that this material is "solid by compression, but ready to flow one way or other, as the pressure may be reduced or increased," is certainly loose, but the context plainly shows Mr. Reade's conception of the material at about thirty miles depth to be that it is *permanently plastic*, and only kept from liquefaction by the pressure of a thirty mile crust above it. If the pressure were *relieved*, it would become liquid; if *everywhere increased*, it would become rigid; but if the plastic zone is deep, and a small area of the crust is weighted and depressed, the plastic material beneath may be displaced (without being made to flow as a liquid) and might have the effect of slightly bulging up the crust around the depressed area. This is Mr. Reade's view, but his use of the word *flow* suggests the idea of the liquidity which he did not mean to convey.

2. Mr. Fisher finds a second difficulty in the fact that the transference of heat from the plastic magma to the depressed crust would take place concurrently with the depression, "so that the swelling up (by expansion) would begin at once." Mr. Reade's own reply to this (Phil. Mag. 1891, p. 491) does not seem very happy: his own book (pp. 93 and 122) affords a better answer; for he says the first accession of heat would be employed in lateral expansion, and in folding and crushing the materials of the crust which underlay the newly-deposited sediments. He thinks the expansion of the lower layers of the weighted crust, being confined by the surrounding tracts and by the weight of the upper layers, would develope internal strains, and that much of the heat would be expended in doing work, *i.e.* in developing a force which would ultimately produce foliation by a process of forcible detrusion, crushing and repacking or reformation of constituents, when at length it became easier for the expansive force to lift the overlying mass of the crust rather than to exercise further lateral compression.

The above are Mr. Fisher's two principal objections to the theory of upheaval by cubical expansion, and he afterwards says, "If the two preliminary difficulties can be disposed of, the theory seems well suited to explain the formation of elevated plateaux. But for producing the intense corrugation, which characterizes most mountain ranges, the amount of horizontal expansion which it affords appears inadequate." In this remark I quite agree with him for reasons which will appear in the sequel.

3. Before, however, we can accept Mr. Reade's theory as a real cause of upheaval, we have to reckon with Mr. Davison, who has published what he regards as a fundamental objection to the theory.[2] He writes, however, as if it was the accumulating sediment only that received an accession of heat, and as if the crust below did not partake in this accession. He says the heat which expands the

[1] Dec. III. Vol. IV. p. 229, 1887.

[1] GEOL. MAG. May, 1891, p. 211.

sediments must be withdrawn from the crust below, that this crus losing heat will contract, and that the expanding sediment wi follow a retreating crust, so that no upheaval will take place at al the total volume of crust and sediment remaining unaltered.

But these are not the conditions of Mr. Reade's theory.[1] Th crust is depressed by the weight of sediment, and it is the lowe part of the original crust which is the first to expand by receivin heat from below. It is true that this only transfers the applicatio of Mr. Davison's argument; the heat is conveyed from one laye to another, and if the crust is receiving heat from the plastic under stratum, the latter will be cooled and lessened in volume *unless it loss is made good.* But what is to prevent the loss from bein made good?

Mr. Fisher has a remark on this point which is quoted by Mr Davison, though he avoids the consideration of it. Mr. Fishe observes that "there can be no absolute increase in the amount o heat beneath the area in question except such as is supplied to i laterally."[2] This means that in his opinion some heat could b supplied laterally, and that heat lost by one part of the interior wil be made good by the conduction of heat from the surrounding part until the temperature of the whole is equalized; this may be a slow process, but it is surely a correct view, and one that Mr Davison is bound to consider.

If the local loss of heat is thus distributed over the whole interna mass of the earth, there will be an absolute increase in the amoun of heat below the sinking area, because the heat gained will b localized in the thickened crust. This thickened crust, compose partly of ancient crust material and partly of recent sediment, wil expand; but how, in what manner, and to what extent, will i expand? These are the questions now before us.

Mr. Reade assumes that as soon as the depressed tract of crus begins to expand, the expansion will be localized and will form a ridge parallel to the longer diameter of the depressed area. He rests this belief on the results of certain experiments and observa tions made on the expansion of metal plates which did so ridge up when heated. But the conditions of these experiments did no resemble those of a weighted crust free to bend downwards, and consequently they do not afford a sound basis for his relief.

The ridging up of the leaden floor of a pantry-sink exposed t alternate expansions and contractions by the contact of hot and cold water; or the heating of a sheet of lead which is *screwed down* t a block of wood, cannot afford any clue to the manner in which expansion would occur in a *lenticular* mass of material, heated from below, slowly sinking and able to expand in almost any direction but especially in any upward direction. Without closely imitating

[1] Mr. Davison informs me that his note had no special reference to Mr. Reade's book, but was simply a criticism on the "fundamental principle" of the expansion theory.

[2] Physics of the Earth's Crust, second edition, p. 123, repeated from the firs edition of 1881.

these conditions, it is impossible to say how such a mass would accommodate itself to the stresses set up by expansion, but it does not seem likely that a mass which is thickest in the centre would "buckle" or ridge itself up along a continuous diametric line; one would think that it was more likely to develope a set of concentric ridges near the edges, if any such ridges were produced at all.

It is quite possible that the crust below such a mass, being held circumferentially by the solid crust around it, would expand within its own area, and the internal compression resulting from this expansion might well produce some plication of the component rock-beds; the expansion would be greatest where the depression was greatest and the combined crust and sediment were thickest, but the plication would be greatest where the mass was thinnest and weakest, and there is no apparent reason why any part should throw itself into a great surface earth-wave; yet that is what Mr. Mellard Reade assumes it would do!

Again, if the expansion could be, or were likely to be, so localized as to cause a gigantic and continuous plication of the crust, the bending is not likely to be entirely upwards. Mr. Reade begins with assuming a plastic substratum; but when he comes to consider the expansion of the crust, he appears to assume a foundation which is rigid enough to support that crust without yielding to pressure. In all probability the compression which would cause an upward anticlinal swelling would force some other part of the bending crust still further downwards into the plastic substratum, and the most probable result would be a central anticline flanked by smaller synclinal plications. It is true that the total extent of the downward displacements would probably be less than that of the upward bulge, but any downward displacement will detract from the available upward expansion, and Mr. Reade requires all he can get for his mountain-building.

One of the most suggestive parts of Mr. Reade's book is his theory of plication by internal expansion (chapter xv.). He points out that if the corrugations of mountain chains have been formed by a compressive force *acting from outside the orographic area*, then the corrugated beds must originally have occupied a much wider space, the space in fact which they would now cover if pulled out straight. This is assumed by most geologists, and, taking it for granted, they have calculated that the breadth of country now occupied by the Alps has been *shortened* by 72 miles, and that occupied by the Appalachians has been shortened by 88 miles, that is to say, two spots, one on each side of the Appalachian Mountains, have been brought nearer to one another by 88 miles, and Mr. Reade asks whether geologists have fully realized what this means.

If, on the other hand, the plications are due or even largely due to the compression produced by the internal expansion of the mass, they result from actual lengthening of the strata throughout the whole breadth of the orographic area, and consequently they do not involve any lateral movement in space. This seems to me a point that is well worth consideration.

It is a question, however, whether the plications are wholly formed by expansive compression; if they are, then they become a measure of the expansion. Now in the case of the Alps the calculated shortening is nearly as great as the actual width of the range; in other words, the expansion must have doubled the length of the beds laterally; (to do this it must have doubled the volume of the solid mass out of which the range was formed.) Let us apply this result to an area of the size used by Mr. Reade for illustrative calculation, viz. one measuring $500 \times 500 \times 20$ miles, which is equal to 500,000 cubic miles. Now if this is doubled by expansion, 500,000 cubic miles has been added to the mass, but the calculated expansion of such a block raised by 1000° F. is only 78,400 cubic miles, and is therefore very far short of the required amount. The conclusion I would draw from this little calculation is that the plications are not wholly due to expansion.

Finally, it seems desirable to point out to Mr. Reade that the assumption of a plastic substratum will not satisfy Sir W. Thomson's demands for the rigidity of the Earth as a whole. Mr. Reade cannot have a substratum that is plastic enough to yield to such a small terrestrial influence as the local accumulation of sediment, while it is rigid enough to resist the deforming tidal influences of the sun and moon. The only way out of this difficulty is the assumption of a liquid substratum saturated with dissolved gas: this is Mr. Fisher's view, and it affords a much more satisfactory basis for the explanation of terrestrial movements.

Postscript.—Correspondence with Mr. Davison leads me to see that although the temperature of the mass below the depressed area will be raised by conduction of heat from the surrounding parts, yet that these surrounding parts will contract in parting with heat; consequently if this conduction is fairly rapid and the further equalization of temperature is a slow process, the mass which is receiving heat may expand laterally into the spaces formed by the contraction of the parts immediately outside it, instead of expanding upwards and raising the depressed crust. Mr. Davison therefore still maintains that no upheaval would result from the expansion of a depressed portion of the crust, and until his argument can be answered it certainly cuts at the root of the expansion theory of surface upheavals.

V.—On the Occurrence of *Xanthidia* (*Spiniferites* of Mantell) in the London Clay of the Isle of Sheppey.

By E. W. Wetherell, F.G.S.

THE vexed question of the affinities of the fossil organisms known as *Xanthidia*—a question which only experienced zoologists and botanists can hope to solve—will not be discussed in this short paper, my intention being merely to show that these interesting organisms are not confined (in England) to the Chalk flints and Grey Chalk, but exist in the London Clay, and to give a short account

of the means of isolation and of the appearance of these minute fossils.

I may here mention that all writers[1] previous to Mr. Henry Deane speak of them as spherical bodies; but these earlier observers, including the discoverer Ehrenberg, had only examined fossil *Xanthidia* in chips of flint; whereas Mr. Deane[2] succeeded in isolating them. Mr. Deane took a fragment of Grey Chalk, obtained from the beach between Folkestone and Dover, and dissolved it in hydrochloric acid, and in the residue he discovered these organisms—which he describes as not being true spheres, but somewhat flattened, having a remarkable resemblance to some gemmules of sponges, and having a circular opening in one of the flattened sides. Mr. Deane adds that on submitting some individuals to pressure between glass plates, they were torn asunder laterally like a horny substance, and the spines in contact with the glass were bent, while some specimens after soaking in water became flaccid showing that they were not siliceous.

Having thus briefly described Mr. Deane's results, I will proceed to the description of the London Clay forms and the method of obtaining them.

My attention was first called to them in the finer siftings of the washing of clay obtained from the cliff near Minster, Sheppey. This clay I obtained at a height of about four feet above the beach, and it is of a greenish colour—all the clay above and below being brown and much more compact. A great number of organisms can be seen in this clay without the aid of a magnifying-glass, whereas the brown clay contains few fossils.

The first specimens of *Xanthidia* found were very much damaged, so I altered the method of washing in the following way. The clay was disintegrated on a piece of perforated zinc immersed in water, and after an hour or so the zinc was gently shaken and all the finer particles went through, leaving the larger fossils, such as Gasteropods, vertebræ, and teeth of fishes, etc., on the zinc, which was then removed, and the finer material was again sifted in the wet state through a wire sieve 90×90 holes to the square inch; this separated out the larger Foraminifera (which exist in this deposit in great numbers of the genera *Cristellaria*, *Marginulina*, *Nodosaria*, etc.), and the finest material was then washed and dried in the ordinary manner, and gave far better results than the material resulting from washing in the ordinary way. A microscopical examination of this finest sifting showed a great number of *Xanthidia*, which for the most part follow two types which can be easily distinguished, although there are a great many minor varieties of each of them. In many cases these organisms are found joined together, in pairs or with five or six individuals massed together.

Their characters are as follows: shape, lenticular; some specimens

[1] Ehrenberg, 1836, Bericht. des Akademie Wissenschaften zu Berlin, p. 114.—*vide* also Abhandlungen Konigl. Akad. Wissenschaften zu Berlin, 1836 (published 1838), p. 114.—Turpin, Comptes Rendus de l'Académie des Sciences, 1837.

[2] Micros. Soc. Trans. Oct. 15th, 1845, vol. ii. p. 77.

far flatter than others, but this may be due to pressure; in some the spines (tentacula of White)[1] appear to be round the edge, and also springing out obliquely from the flattened sides, and in others they appear to be round the edge only. The flattened surface of the organism is very variable in shape, sometimes almost truly circular, in other cases elongated, and often very irregular in contour.

The length, thickness, and number of these spines varies very considerably, giving rise to the two types above referred to. One type has the central body-portion circular and small with a large number of regular radial spines, almost as long as the diameter of the body portion, and very thin, the ends much branched. The other type has a much larger body, more irregularly shaped, fewer, shorter and thicker spines, which branch out very irregularly, crowded together in one part and scanty in other parts.

When viewed by reflected light, *Xanthidia* appear to be white, or pale brownish, and the spines are transparent. If seen by transmitted light, however, when mounted in glycerine, the body portion becomes more or less translucent, and is of a distinct green colour. This greenish body contains black spots, and in some few cases the whole body, except the very edge, is opaque. Glycerine shows the whole form better than any other medium, Canada Balsam having an index of refraction which prevents the spines being seen. These spines can be bent by pressure when wet.

Saffronine stain was taken up by the body, but the spines were but little affected.

The diameter of these minute organisms is about $\frac{1}{10}$ mm., coinciding exactly with the measurement of the Chalk forms.

With reference to the greenish clay which contains *Xanthidia*, I should mention that it is not a distinct bed or band, but a patch, and contains great quantities of fish-remains (vertebræ, spinous processes, otoliths, scales, etc.), besides the Mollusca and Foraminifera. Although a patch, it occurs in a band of somewhat laminated clay, which I have traced for several hundred yards along the cliffs, in which occur other fossiliferous patches, which do not contain *Xanthidia*, as far as I have been able to see, although I have examined several samples. The *Xanthidia* patch, as I found it, was about a yard long, some three or four inches thick, and extended about eighteen inches or possibly farther, into the cliff; but near that point the clay appeared less fossiliferous to the naked eye, and was probably at the end of the patch.

I wish to mention that, through the kindness of Prof. Judd, the work in connexion with this paper was performed in the geological laboratory of the Royal College of Science, South Kensington.

[1] H. H. White, Trans. Micros. Soc. vol. i. p. 77, on Fossil *Xanthidia*, Feb. 1842.

NOTICES OF MEMOIRS.

I.—Étude Micrographique du Tuffeau à *Cyprina planata* du Nord de France et de la Belgique. Du Role des Diatomées dans la Formation de ce Tuffeau (Notice préliminaire). Par M. L. Cayeux, Préparateur de Géologie à la Faculté des Sciences de Lille. Annales de la Société géologique du Nord, t. xix. 1891, pp. 90–95.

THE Tuffeau described in this paper is a rock consisting of glauconitic sands agglutinated together by a siliceous cement, which is of not infrequent occurrence in the Sands of Landenian age in many localities in the North of France and in Belgium. The horizon of *Cyprina planata* appears to be slightly lower than that of the Thanet Sands of this country. In some places, near Lille for example, the rock is remarkably rich in zircon, tourmaline and rutile. The author has also discovered therein abundant remains of Diatoms and sponge-spicules; the former principally belong to the genera *Synedra, Coscinodiscus* and *Triceratium*, whilst the latter are chiefly of Monactinellid and Tetractinellid sponges. Sometimes the Diatoms prevail in the rock; at others the spicules. The silica forming the cement of the rock may be either in the condition of opal or chalcedony, and thus resembles the silica of the organisms. The author considers that this cementing silica has, in part, if not altogether, been derived from the remains of the diatoms and sponges. In a subsequent note in the same journal (p. 134) mention is made of the occurrence of Diatoms in the upper portion of the Ypresian of Flanders, thus on the horizon of the London Clay. From the character of the minerals in the Tuffeau and sands of the Lower Eocene, the author concludes (p. 265) that they have been primarily derived from the crystalline-schist series of rocks.

G. J. H.

II.—Palæozoic Fossils from Kotelny Island, New Siberia. By Baron Eduard von Toll. Mémoires de l'Académie Impériale des Sciences de St.-Pétersbourg, vii^e^ série, vol. xxxvii. No. 3, 1889.

THIS is the first portion of the Scientific Results of the Expedition sent out in 1885–6 by the Royal Academy of Sciences for the Exploration of Jana-Land and the New-Siberian Islands. Prefatory remarks (pages 1–9) give an account of the Expedition, its aim, progress, members, and helpers. A description of the fossiliferous Devonian strata of the West Coast of Kotelny Island (pages 10–13) precedes that of the fossils, which comprise 23 species and varieties of Brachiopods, 6 Corals, and 2 Stromatoporoids. Eight forms are peculiar to this region, and a table at p. 32 shows the distribution of the others in Siberia, West side of the Ural, Petchora-land, Rhine-land, North America, or China, in the upper division of the Middle-Devonian formation.

The Silurian fossils, chiefly from the gravel of the Ssrednjaja river, are 7 Brachiopods, 4 Trilobites, 6 Ostracodes (*Leperditia*), 12 Corals,

1 distinct (*Lagena*) and 5 indistinct sections of Foraminifera. The distribution of these species in the Upper-Silurian formations of Siberia, Estland and Oesel, Scandinavia, Britain, China, and America is shown in a table at p. 55. *Strophomena euglypha, Phacops quadrilineata, Favosites Gotlandica, F. Forbesi, Alveolites Labechei, Heliolites interstinctus,* and *Halysites catenularia* have the widest range. Five quarto plates of numerous figures illustrate this interesting memoir.

T. R. J.

REVIEWS.

I.—The Fauna of the Lower Cambrian or Olenellus Zone. By Charles Doolittle Walcott, F.G.S., of the Smithsonian Institution, Washington, D.C., U.S.A. Extract from the Tenth Annual Report of the Director (1888–89). Washington, 1890 (issued 1891). U. S. Geological Survey. 4to. pp. 511–774, Plates xliii.–xcviii.

THE publications of the Geological Survey of the United States of America have long been famous for their illustrations and their typography; for the vast amount of economic information they contain as regards the stratigraphical geology, the physical features, the agricultural and mineral resources contained in each State. Nor has science been neglected, for there are but few volumes, out of the long and splendid series already issued, which have not contained most valuable contributions to the palæontology of some group of organisms, or the fauna of some series of rocks. This is all the more honourable to the present Director, Major J. W. Powell, because it is an open secret that, *like Gallio,* "*he cares for none of these things,*" and might, if ungenerously disposed, have placed great obstacles in the way of the progress of palæontology. We have now to thank him for enabling Mr. C. D. Walcott, the author of the memoir before us, to bring out in a suitable manner, one of the finest pieces of work which has issued from the Government Printing Office, Washington, already famous for its productions, so generously distributed by the United States Government to men of science all over the world.

The author, with the modesty of true merit, prefaces his work (pp. 516–524) with the names of some forty authors and over one hundred papers bearing upon Cambrian geology and palæontology. Mr. Walcott thus defines the title of his work:—

"A living fauna, as known to the zoologist, is the assemblage of animals embraced within a given geographic province or area, and includes all animal life associated on account of climate or physical boundaries. Some of the species may range from province to province and form a part of several faunas, while others are limited to a particular portion of some faunal area.

"In the study of the extinct faunas, buried in the rocks, the same general principles of classification prevail, with the added restriction of vertical or time range as defined by the progressive zoologic changes in the faunas.

"There is not a sufficient assemblage of species found in the oldest rocks in which animal life has been detected to constitute a fauna that can be characterized either as distinct from the succeeding fauna or as belonging to that fauna. At present the first recognized fauna occurs in the lowest division of the Cambrian group. In nearly all the localities where this lowest zone is recognized a peculiar genus of Trilobites, *Olenellus*, is found; and thus the name 'Olenellus fauna' and 'Olenellus zone,' have come into general use. By the palæozoologist the fauna is called the Olenellus or Lower Cambrian Fauna. To the geologist the series of rocks in which the Olenellus fauna occurs is known as the lower division of the Cambrian group or 'Olenellus zone'" (p. 515).

In addition to a most valuable list, already referred to, of all the more important books and papers relating to the subject, the author gives a historical review of the work done on the rocks and fossils included in the Olenellus zone, and the general results of the study of the fauna by the geologist and palæontologist, or its physical biological history and character as far as is known.

The geologist considers it as found in certain rocks at a distinct geologic horizon and studies its geologic relations. The palæozoologist treats of it in its relations to the animal world, past and present.

Mr. Walcott first traces back the history of the Lower Cambrian strata in America to 1818, when Prof. Amos Eaton first gave them a definite position in the series of stratified rocks. Passing in review the records of each writer, he shows the gradual development of the history of this series of rocks and gives the ancient and modern nomenclature by which it has been distinguished, and the areas over which it has been observed.

Mr. Walcott shows that the Lower Cambrian, or Olenellus fauna, lived along the shores of the pre-Cambrian continent which from east to west was almost co-extensive with that of the N. American continent of to-day. That it has been observed in the north-west at Mount Stephen, British Columbia; at Eureka district, British Nevada; in Northern Arizona, in the Grand Cañon of the Colorado; on the western slope of the Wasatch Mountain; on the Gallatin River, Montana; on the Black Hills of Dakota; in Wisconsin and Minnesota; on the Ozark Mountains, Southern Missouri; and even as far south as Llana County, Texas; in Eastern Tennessee; Eastern and Northern Adirondack Mountains of New York; and Green Mountains; North Attleborough and Braintree; at St. John's, New Brunswick, far northwards; at l'Anse au Loup, N. side of Straits of Belle Isle, Labrador; and lastly in the extreme N.E. at Conception Bay, Avalon Peninsula, Newfoundland.

All this is graphically illustrated by a map (pl. xliv.), and by very numerous sections and plates (pl. xlv.–xlvii.).

Plate xlviii. shows in the same graphic method the extension eastwards into Europe of probably the same series of unconformable pre-Cambrian rocks on which the Cambrian series rest. These are shown in Spain, in Wales (North and South); and we may now

add the North-West Highlands; in Norway and Sweden; in Finland; in Bohemia and Bavaria; in Sardinia; in Podolia; in Petchora land and the Ural Mountains. Perhaps the most astonishing part of this new page of early geological history, to the deciphering of which Mr. Walcott has brought such skill and ability, is that which relates to the fauna, the mere names of which, in column, fill four pages. Here is the summary, written in a very compact manner by the author (p. 576).

RESUME OF THE FAUNA OF THE OLENELLUS ZONE IN AMERICA.

Classes, etc.	Numbers.		
	Genera.	Species.	Varieties.
Spongia	4	4	0
Hydrozoa	2	2	0
Actinozoa	5	9	0
Echinodermata	1	1	0
(Trails, Burrows, and Tracks)...	4	6	0
Brachiopoda	10	29	2
Lamellibranchiata	3	3	0
Gasteropoda	6	13	5
Pteropoda	4	15	2
Crustacea	5	8	0
Trilobita	15	51	2
Total	59	141	11

Uniting all the fossils of this zone found by our English geologists, Drs. Hicks, Lapworth, etc., in Wales and Shropshire; by Dr. Schmidt in Russia; by Profs. Kjerulf, Linnarsson, Torell, Brögger, Holm, Nathorst, and others in Sweden and Norway, and those from the other European localities, the numbers are extremely small, at present, when compared with those recorded on the American Continent; nevertheless the facies is one that clearly admits of perfect correlation.

Mr. Walcott is also able satisfactorily to show now that the *Olenellus* fauna *preceded* the *Paradoxides* fauna. "The cause of the abrupt change from the *Olenellus* to the *Paradoxides* faunas is not yet fully recognized. While a considerable portion of the genera pass up, very few of the species are known to do so, and in none of the sections has there been found a commingling of the characteristic species of the Lower and Middle faunas" (p. 594).

"If we attempt to classify the *Olenellus* fauna by its genesis, an almost impenetrable wall confronts us. That the life in the pre-*Olenellus* seas was large and varied there can be little, if any, doubt. The few traces known of it prove little of its character, but they prove that life existed in a period far preceding Lower Cambrian time, and they foster the hope that it is only a question of search and favourable conditions to discover it. As far as known to me, the most promising area in which to search for the pre-*Olenellus* fauna is on the western side of the Rocky Mountains in the United

States, and on the eastern slopes in British Columbia. There the great thickness of conformable pre-*Olenellus* zone strata presents a most tempting field for the student-collector" (p. 595).

As the author remarks, a considerable number of the genera and species included in this Monograph have already been described at length and figured in Bulletin No. 30 of the U. S. Geological Survey (1886). Beginning with the sponges, which are by no means numerous, we find Salter's genus *Protospongia* represented by detached spicules of the usual type, and portions of the anchoring rope of another hexactinellid sponge, similar to those usually referred to *Hyalostelia*, Zittel, have been placed by the author in a distinct genus, *Leptomitus*. It may be remarked that since the discovery, by Sir J. W. Dawson, that certain species of *Protospongia* possessed anchoring spicules, it is not improbable that forms like this *Leptomitus* may be found to belong to the former genus. The above are the only definite sponges known from the Lower Cambrian, for the specimens of *Girvanella*, even if they really belong to this genus, have no claim to be considered as sponges, and they are now believed to be calcareous algæ. The position of another new form, *Trachyum vetustum*, appears to be very uncertain, the description leads one rather to consider it a member of the next group of the Archæocyathinæ. This group is very fully represented in the Lower Cambrian of Nevada, New York and Labrador, and very good figures are given to illustrate the structure of the different genera. The author follows Hinde in placing these peculiar forms in the Actinozoa. Very considerable interest attaches to them, since they appear to be characteristic of the Lower Cambrian, not only in America, but in Spain and Sardinia, and, as lately shown by R. Etheridge, jun., in South Australia as well.

Of the fine series of plates which illustrate the fauna of the *Olenellus* or Lower Cambrian Zone, plate xlix. is devoted to *Leptomitus Zittelli* and *Protospongia* sp.? two forms of Sponges; plates l.–lv. to a series of figures of different forms of the Archæocyathinæ, in some of which structure and ornament are preserved. Plates lvi.–lix. to forms referred to the Hydrozoa. Plates lx.–lxvi. to Echinodermata, Annelida, and Crustacea, being tracks, trails, and Annelide- and Crustacean-burrows of all kinds. Plates lxvii.–lxxii. are devoted to a series of Brachiopods—*Lingulella, Acrotreta, Linnarssonia, Kutorgina, Iphidea, Acrothele, Mickwitzia, Obolella, Camarella, Orthis*, and *Orthisina*, mostly well-preserved and well-defined species. Then follow plates lxxiii.–lxxiv., devoted to Lamellibranchs and Gasteropods, in which Patella-shaped forms predominate. Plates lxxv.–lxxix. are devoted to Pteropods (under which are included *Salterella, Hyolithes, Helenia, Coleoloides, Volborthella*, and *Platysolenites*. The remaining plates, pls. lxxx.–xcviii., are devoted to the Crustacea, and principally to the Trilobites. A few Ostracods and *Leperditia*, with *Agnostus* and *Microdiscus*, occupy plates lxxx. and lxxxi., followed in the remaining plates by a grand series of *Olenelli* which would have rejoiced the heart of J. W. Salter, could he but have lived to see and gloat over them. Trilobites—many of

them at least—with the third thoracic segment drawn out into a long pleural spine on either side, giving them a most weird appearance (these are occasionally curled round, as in *Olenellus Gilberti*). In *Mesonacis Vermontana*, the abdomen is elongated into 12 or 13 segments, with a powerful median dorsal spine rising from the proximal segment, and reaching to the end of the body; in *M. asaphoides* there are five of these spines; in *Holmia Brögger*i spines are present down the centre; the nuchal median spine being equal in length to nearly seven of the body segments.

This form is no doubt most nearly related to Professor Lapworth's *Olenellus Callavei*, but there are well-marked differences between them, when carefully compared, both in the head-shield, body-segments, and spines. *Olenellus* (*Mesonacis*) *Mickwitzii* and *O.* (*Holmia*) *Kjerulfi*, the former a Russian form and the latter from Sweden, suggest new departures in spines and tubercles and a facies diverging towards *Paradoxides* of the Middle Cambrian, but with marked differences. The spine, on the axis of the Russian form, reminds one of the genus *Cyphaspis*.

There is a common family-likeness in all these *Olenelli*, but they run through a great variety of form, amounting in some probably to generic value, as pointed out by Mr. Walcott. This is strikingly the case if we compare his *Olenellus Thompsoni* with *Olenellus* (*Holmia*) *Kjerulfi*, and *Olenellus Gilberti* with *Olenellus* (*Mesonacis*) *Vermontana* and *O.* (*Mesonacis*) *Mickwitzii*.

Sixty-one pages are occupied (pp. 597–658) with carefully prepared Notes on the genera and species of the fauna of the *Olenellus* Zone, and the work concludes with what all works should possess, namely, a good index.

We heartily congratulate the author upon having had the honour to bring together so admirable a Monograph upon a new or but little understood formation, which has apparently so remarkable a geographical range, and possesses such a well-marked fauna wherever it has been observed. Such discoveries in the geology and palæontology of the oldest Palæozoic rocks may well serve as an incentive to future workers, and clearly show that much yet remains to be done in order to complete our knowledge of the fauna of these ancient seas.

II.—A Monograph of the Carboniferous and Permo-Carboniferous Invertebrata of New South Wales. Part I. Cœlenterata. By R. Etheridge, jun., Palæontologist and Librarian to the Geological Survey of New South Wales, etc. Memoirs of the Geological Survey of New South Wales. By C. S. Wilkinson, F.G.S., etc., Geological Surveyor-in-Charge. 4to. pp. ix. 64. Pls. I.–XI. (Sydney, 1891.)

THE Geological Survey of New South Wales, with the view of extending a knowledge of the coal-bearing formations in that colony, has determined to publish fresh descriptions of the invertebrate fossils in these rocks, which have been collected by the

Survey, and are now in the Mining and Geological Museum at Sydney, and the present work relating to the fossil Corals, by Mr. R. Etheridge, jun., Palæontologist to the Survey, is intended as a first instalment.

The subdivisions of the Carboniferous rocks of New South Wales are at present under revision; according to the arrangement provisionally adopted, the strata below the Farley Group of the Lower Marine Series are considered as Carboniferous simply, whilst this Lower Series and the Upper Marine Series, which are intercalated with the productive Coal-measures, are regarded as Permo-Carboniferous. In these rocks corals are, as a rule, scarce and poorly preserved, with the exception of species of *Zaphrentis* and the Monticuliporoid genus *Stenopora*. Of the former genus seven species are described, three of which, *Z. Culleni*, *Z. phymatodes*, and *Z.? sumphuens*, are new forms. Some of these exhibit a remarkable infilling of the calyx and thickening of the septa with sclerenchyma; features which are very prominent in *Plerophyllum*, Hinde, but as they do not show the 4 or 5 characteristic large septa of this latter genus, it may be doubted whether they can rightly be included in it. Other species described are *Lophophyllum corniculum*, de Kon., *Campophyllum columnare*, sp. nov., *Cyathophyllum* (?) *zaphrentoides*, sp. nov., *C. retiforme*, sp. nov., and *Aulophyllum Davidis*, sp. nov. Of perforate corals a new species of *Trachypora*, *T. Wilkinsoni*, is described, which, in many of its characters, resembles *Striatopora*; also *Michelinia* sp., allied to *M. tenuisepta*, Phillips, and *Cladochonus tenuicollis*, M'Coy.

A very full and elaborate description of the minute structural characters of the genus *Stenopora* is given, and the three species described by Lonsdale, *S. crinita*, *S. ovata*, and *S. Tasmaniensis*, are recognized, although the author is inclined to believe that they do not represent separate and distinct species, but merely different conditions, which seem permanent in certain circumscribed areas.

The investigations which have lately been made into the minute structure of *Stenopora*, and other Monticuliporoids, clearly show that these fossils possess a similar minute structure of their walls to forms which are generally recognized as Polyzoa, and if any value is to be attached to this similarity in microscopic detail, there is no doubt that *Stenopora*, in common with the other genera of this group, will no longer be able to rank as corals. Mr. Etheridge does not enter into this question, but follows the views of Nicholson, and of Waagen and Wentzel, that they are really allied to corals. In its massive mode of growth, a form like *Stenopora crinita*, which sometimes reaches six inches in diameter, certainly approaches in appearance more nearly to corals than to polyzoa; but on closer consideration this massive structure is seen to be built up of a series of layers which, in certain states of preservation, as remarked by Mr. Etheridge, peel off, one after another, leaving an entirely new surface after each operation. In the mass, *S. crinita* has a wonderful resemblance to the large *Chætetes radians* from the Carboniferous

Limestone of Russia, but microscopic sections of the two forms at once show that the structure of this latter is that of a coral, whilst the former is altogether distinct, and, as already mentioned, resembles that of generally recognized Palæozoic Polyzoa.

Without reckoning *Stenopora* with its three species, there are only nine genera and seventeen species of corals known in the Carboniferous rocks of New South Wales, a small number when compared with those of the corresponding formations in Europe, or with those of the Siluro-Devonian period of Australia.

Mr. Etheridge's descriptions are amply illustrated in the eleven plates accompanying this report, which at once sustains the reputation of the author, and bears witness to the enlightened encouragement of palæontological science by the Government of the Colony.

III.—On the Probable Nature and Distribution of the Palæozoic Strata beneath the Secondary, etc., Rocks of the Southern Counties; with Special Reference to the Prospect of obtaining Coal by boring South of the Mendips. By W. A. E. Ussher, F.G.S. [Proc. Somerset Arch. and Nat. Hist. Soc. vol. xxxvi. 1891.]

THE probable occurrence of productive Coal-measures on the southern side of the Mendip Hills has been discussed since 1826, when Buckland and Conybeare first wrote on the geology of that region (see Geol. Mag. 1871, p. 500); but no one at present has put down any boring sufficiently deep to prove the nature of the Palæozoic floor over the area where these buried Coal-measures are likely to occur. The subject is treated from a broad point of view by Mr. Ussher in the paper under consideration. Referring to the Culm-measures of Devonshire, he points out that there is no reason to believe that the easterly development of this comparatively unproductive series, would affect the question of true Coal-measures being reached in the area south of the Mendips. The Culm-measures include representatives of the Carboniferous Limestone, Millstone Grit, and possibly [we would say probably] the lower part of the Coal-measures; but eastwards near Burlescombe and at Cannington Park the Limestone becomes more prominently developed, and it therefore is likely that further east and north-east the Carboniferous beds generally would approximate more and more closely to the characters they have in the Mendip area and in the Somersetshire Coal-field.

From a general consideration of all the facts, and especially with reference to observed dislocations in the older rocks of West Somerset, Mr. Ussher concludes that the most probable location of an underground Coal-basin in the area south of the Mendips, would be enclosed by an irregular line drawn from the coast near Otterhampton, through Pawlet and Meare, to Polsham; from Polsham to Wedmore, and thence by Badgeworth and Lympsham to the coast at Brean. Within this line the best sites for trial borings would be in the vicinity of Highbridge, Burnham, and Berrow; at East or South Brent, Chapel Allerton, Wedmore, Meare,

and Mark. The depth of strata likely to cover the Palæozoic floor at these places might be expected to vary from four or five hundred to a thousand feet, but it is improbable that it would anywhere exceed a thousand feet.

In connection with the disturbances to which the Mendip area has been subjected, Mr. Ussher introduces a diagram to explain by means of a thrust-plane the occurrence of the little masses of Carboniferous Limestone that overlie the Coal-measures at Vobster on the northern side of the Mendip anticline. H. B. W.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—Nov. 11, 1891.—Sir Archibald Geikie, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "On *Dacrytherium ovinum* from the Isle of Wight and Quercy." By R. Lydekker, Esq., B.A., F.G.S.

The author described a cranium and mandible of *Dacrytherium Cayluxi* from the Quercy Phosphorites, which proved the identity of this form with the *Dichobune ovina* of Owen from the Oligocene of the Isle of Wight. The species should thus be known as *Dacrytherium ovinum*. It was shown that the mandible referred by Filhol to *D. Cayluxi* belongs to another animal.

2. "Supplementary Remarks on Glen Roy." By T. F. Jamieson, Esq., F.G.S.

The author discusses the conditions that preceded the formation of the Glen Roy Lake, and appeals to a rain-map of Scotland in support of his contention that the main snowfall in Glacial times would be on the western mountains. He gives reasons for supposing that, previously to the formation of the lake, the valleys of the Lochaber lakes were occupied by ice, and that the period of the formation of the lakes was that of the decay of the last Ice-sheet.

He supports the correctness of the mapping of the terraces by the officers of the Ordnance Survey, and shows how the absence of the two upper terraces in Glen Spean and of the highest terrace in Glen Glaster simplifies the explanation of the formation of the lakes by ice-barriers.

The alluvium of Bohuntine is considered to be the gravel and mud that fell into the lake from the front of the ice when it stood at the mouth of Glen Roy during the formation of the two upper lines.

During the last stage of the lake, the ice in the valley of the Caledonian canal is believed to have constituted the main barrier, whilst the Corry N'Eoin glacier played only a subordinate part.

The author suggests the possibility of a *débâcle* during the drop of water from the level of the highest to that of the middle terrace; and in support of this calls attention to the breaking down of the moraines of the Treig glacier at the mouth of the Rough Burn. He believes that when the water dropped to the level of the lowest

terrace, it drained away quietly, at any rate until it receded from Upper Glen Roy.

In discussing Nicol's objections, he maintains that notches would not be cut at the level of the *cols*, and observes that the discrepancy between the heights of the terraces and those of the *cols* has probably been increased by the growth of peat over most of the ground about the watersheds.

The horizontality of the terraces is stated to be a fact, and cases are given where waterworn pebbles are found in connexion with the "roads," these being especially noticeable in places where the south-west winds would fully exert their influence, and the structure of the terraces is considered to be such as would be produced at the margins of ice-dammed lakes. Further information is supplied concerning the distribution of the boulders of Glen Spean syenite. These are found on the north side of the Spean Valley at the height of 2000 feet above the sea and 1400 feet above the river, and fragments of the syenite have been carried towards the north-east, north, and north-west.

In an Appendix, the author discusses Prof. Prestwich's remarks on the deltas, and his theory of the formation of the terraces.

II.—Nov. 25, 1891.—Sir Archibald Geikie, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "On the Os pubis of *Polacanthus Foxi*." By Professor H. G. Seeley, F.R.S., F.G.S.

Hitherto the evidence of the systematic position of *Polacanthus* has not been very precise. The author has detected the missing pubis as an isolated specimen. This he regards as the anterior portion of the left pubis, and appends a full description of the bone. He furthermore gives a critical account of our knowledge of other pelvic bones of the genus, and is led to associate *Agathaumus*, *Cratæomus*, *Omosaurus*, and *Palacanthus* in near alliance, in the Scelidosaurian division of the Order *Ornithischia*.

2. "A Comparison of the Red Rocks of the South Devon Coast with those of the Midland and Western Counties." By Professor Edward Hull, LL.D., F.R.S., F.G.S.

The author believes, with Dr. Irving, that the Red Rocks of Devonshire are representatives of the Permian and Trias, which occupy so large a portion of the district bordering Wales and Salop, and which extend into the Midland Counties, and comments on the remarkable resemblance between the representative beds on either side of the dividing ridge of Palæozoic rocks which underlies East Anglia and emerges beneath the Jurassic strata in Somersetshire.

He believes that the breccia forming the base of the series in the Torquay district is a representative of the Lower Permian division, but differs from Dr. Irving, in assigning the red sandstones and marls of Exmouth to the Trias, and not to the Permian, as that author has done. He compares them with the Lower Red and Mottled Sandstones, and regards the Marls as of local origin, thus causing the beds to diverge from the normal type.

The Budleigh Salterton Pebble-beds, with overlying sandstones and pebbly beds, he assigns to the horizon of the Pebble-beds of the Midland area, and points out that fossils of Silurian and Devonian types occur in the pebbles of both areas.

The Upper Division of the Bunter is well shown at Sidmouth, and the author takes a calcareous breccia, two feet thick, which is found in the cliffs, as the basement bed of the Keuper division.

3. "Supplementary Note to the Paper on the 'Red Rocks of the Devon Coast-section,' Q.J.G.S. 1888." By the Rev. A. Irving, D.Sc., B.A., F.G.S.

In this note the author accepts Prof. Hull's determination (see above) of the breccia at Sidmouth as the base of the Keuper, and discusses the age of the sandstones containing vertebrate remains discovered by Messrs. Whitaker, Metcalfe, and Johnston-Lavis. He brings forward evidence in support of his view that these are really of Upper Bunter age, notwithstanding the character of the organisms.

He adds new material in support of his contention that the sandstones and marls which Prof. Hull assigns to the Lower Bunter are really Permian; but he is inclined to think that the breccias (in part, at least) pass laterally into the sandstones, and do not underlie them.

From this it follows that the break between the Permian and Trias of Devon is marked by the absence of the Lower Bunter of the Midlands, and the author quotes remarks of Mr. Ussher in support of his view that there is an unconformity at the base of the Pebble-bed.

In conclusion the author refers to the difficulties of ascertaining the exact age of the breccias, and notes that we cannot prove that the highest Carboniferous beds are present in Devonshire. He observes that there is no valid reason why the great breccia-sandstone series of Devon should not be the true equivalent of the Lower Rothliegendes both in time and position in the sequence, and that some portions of them may be even older than the Rothliegendes of some districts. He discusses the evidence furnished by the igneous rocks, and points out the abnormal position both for the British and German areas which these would occupy, if the breccias were of Triassic age.

III.—December 9, 1891.—Sir Archibald Geikie, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Rocks mapped as Cambrian in Caernarvonshire." By the Rev. J. F. Blake, M.A., F.G.S.

In this paper the following is given as a definite succession in the Cambrian series:—1. Pale Slates; 2. Upper Purple Slates; 3. St. Ann's Grit; 4. Lower Purple Slates; 5. Rhiw-wn Grit; 6. Hard banded Pale Slates and Hälleflintas; 7. Bangor Conglomerate; 8. Hard banded Pale Slates and Hälleflintas; 9. Bangor Breccia; 10. Blue blanded laminated Grits; 11. Tairffynnon Conglomerate; 12. Blue banded laminated Grits; 13. Brithdir quartz-felsite Grit.

The general succession is argued to be the same in the isolated portion east and south of Bangor as in the main mass. The existence or otherwise of a base on the mainland is considered to depend on the age assigned to the Dinorwic felsite, and the presence of the summit-beds to depend on whether the Bronllwyd Grit (stated to belong to the overlying group) rests conformably or unconformably on the Cambrian rocks.

It is argued that the rocks to the west of the Llyn Padarn felsite belong to the lower part of the series and those to the east to the upper, and that the felsite is a volcanic complex belonging to the middle of the Cambrian period.

A post-Cambrian age is assigned to the conglomerates of Moel Tryfan and Llyn Padarn, thus causing the break at the base of the Silurian system to assume an increased importance.

2. "The Subterranean Denudation of the Glacial Drift, a probable Cause of submerged Peat and Forest-beds." By W. Shone, Esq., F.G.S.

A description is given of a section at Upton, Cheshire, where Boulder-clay rests upon the "mid-glacial sands." The Boulder-clay sinks to a lower level in the small valleys which are cut through into the sands; and the author supposes that this is due to the subterranean denudation of the sands, which would be greatest near the valleys, and become less at a distance from them. He considers such denudation is capable of producing submerged peat and forest-beds, and accounts for the splitting of peat-beds, as described by Mr. G. H. Morton, by a somewhat similar action, which he believes may have also operated in Carboniferous times, causing the splitting of coal-seams.

3. "High-Level Glacial Gravels, Gloppa, Cyrn-y-bwch, near Oswestry." By A. C. Nicholson, Esq. Communicated by W. Shone, Esq., F.G.S.

These gravels are found at Gloppa, and are situated at a height of from 900 to 1160 feet above sea-level, on the eastern slope of a ridge of Millstone Grit which forms the western border of the Cheshire and Shropshire plain.

The beds present the appearance of having been abruptly cut off on the north-eastern slope. The gravels are in places much contorted, and false-bedding is frequent. They contain numerous striated erratics. Amongst the boulders are Silurian grits and argillites, granites like those of Eskdale, Criffel, etc., Carboniferous rocks, Lias shale, and Chalk flints. The shells are often broken, rolled, and striated, but the bulk of them are in fairly good condition.

A list of the shells is given, including nine Arctic and Scandinavian forms not now living in British seas, nine northern types, also found in British seas, two southern types, and nearly fifty species of ordinary British forms. Comparative lists of the shells of Moel Tryfan and of those now living in Liverpool Bay are placed side by side with the list of shells from Gloppa.

CORRESPONDENCE.

GRANITE CUTTING CRETACEOUS ROCKS—A CORRECTION.

Sir,—In my Presidential Address to the Geological Society in 1885 (Proc. Geol. Soc. vol. xli. p. 75), I speak of having seen in the Alps "perfectly typical granite cutting Lower Cretaceous strata." The remark was founded on a note made in 1874. I am sorry to say that in these words there are two mistakes: the rock is of Tertiary not of Secondary age: the granite is not intrusive. As to the former matter I was misled by a small map, the only one which I then possessed; as to the latter I fell into a trap. The rock looked like a dyke of grey, not very coarse, granite cutting through a dark schistose rock. I was puzzled at not finding more distinct evidence of contact metamorphism; but this solitary slab-like mass in its general form so closely resembled a dyke, that I did not at that time suspect its true nature. Shortly after the above statement was published, a correspondent (I think Prof. Vélain) intimated to me that he believed I had made a mistake; my own doubts kept increasing; and last summer I again visited the spot, which is on the road from Sepey to Ormond Dessus.

The apparent dyke is one of those large erratics which occur not unfrequently in the *Flysch* of Switzerland, and others may be found at no great distance. How it was that I missed them on the former occasion, and thus failed to have suspicions awakened, I cannot understand, unless it be that changes have been made in the road. Possibly, as I had then worked but little at rocks, something else may have diverted my attention. Be that as it may, there can be no doubt that I made a mistake, and hope that there are not many such on my geological conscience.

T. G. Bonney.

NOTE ON MR. HUTCHINGS'S PAPER ON SOME LAKE-DISTRICT ROCKS.

Sir,—As far as the evidence of the rock-sections goes, the rock from Thornthwaite Crag, described by Mr. W. M. Hutchings, may well be an altered trachyte (Geol. Mag. 1891, p. 543). But the analysis given would indicate a rock nearer andesite, like so many of the "oligoclase-trachytes" of the Auvergne. Considering how trachytes and andesites are associated in the field, and how the same lava-flow may contain varying proportions of porphyritic crystals in various parts, and may consequently yield alkalies in different proportions on analysis of different specimens, I think we must receive with caution the suggestion of an occult rather than a purely chemical cause for the differences between the crystallized constituents of the two types of rock. The analysis referred to by Mr. Hutchings as given in "Aids in Practical Geology" (p. 226 of that book) is that of a *Sodalite*-Trachyte of Ischia. Now I suspect that, had chlorine not been present, this rock would have developed albite and oligoclase in sufficient quantity to bring it at least to the verge of the andesite series. If we call the sodalite

an "accessory" mineral, and deduct the soda required for its formation, we still have an excess of soda over potash in the rock; the monoclinic felspar present at Scarrupata, Ischia, is, no doubt, as is frequently the case, a soda-orthoclase. Such an analysis must not be regarded as typical of simple trachytes, but of the sodalite-trachytes, which, indeed, approach the phonolites. Judged by the bulk-analysis, then, the rock so clearly described by Mr. Hutchings has an affinity with the nepheline-trachytes (nepheline-phonolites) or the trachytic andesites. I fear any trace of original nepheline will have disappeared.

DUBLIN, *5th Dec.* 1891. GRENVILLE A. J. COLE.

CONCRETIONS IN MAGNESIAN LIMESTONE.

SIR,—If I am correct in thinking that Mr. Jukes-Browne considers that Carbonate of Lime was precipitated on the sea-floor during the formation of the Magnesian Limestone beds, I am inclined to agee with him; but this merely deals with the origin of beds of Magnesian Limestone, and does not account for the formation of the Concretions. If, however, he intended to suggest that the moisture contained in the deposit held the Carbonate of Lime in solution, I think the amount would be quite inadequate to account for the thick beds of concretions, and this method of origin would not explain the bedding planes which pass uninterruptedly through matrix and concretions alike. E. J. GARWOOD.

THE LATE P. HERBERT CARPENTER, M.A., D.Sc. (CAMB.) F.R.S., F.L.S.

The Editor has received the following note from Mr. FRANK SPRINGER, joint-author with Mr. Wachsmuth of numerous works and memoirs on the N. American Crinoidea. It is a high tribute of regret, regard and esteem from the United States for the loss of one whom we all deeply and sincerely mourn in England.—EDIT. GEOL. MAG.

DEAR Dr. WOODWARD,—It is with the most profound regret that I have learned the particulars of the death of our lamented friend Carpenter. It is difficult to aptly express the great loss it is to Wachsmuth and myself. Carpenter's rare scientific attainments and broad learning are known wherever Zoologists exist, but to us, who have been in constant correspondence with him for fourteen years, I think his untimely death brings a keener sorrow than to any outside of the circle of his intimate friends and relations. We had the greatest reason and opportunity to admire and appreciate him. Notwithstanding our many animated controversies in print upon disputed questions of Echinoderm morphology, and still more numerous and earnest battles in private correspondence, in which many a promising theory was warmly advocated, combated, and given up on both sides, our acquaintance long ago assumed the phase of cordial friendship and high personal regard. This was still more firmly cemented by my visit to him, while in England in 1887–8, and we feel his loss now as a personal bereavement. We

were in the most confidential communication relative to our various works on the Crinoids, especially the one now in progress. We always interchanged advance sheets of our publications, and sometimes sent each other manuscript for examination and criticism. Carpenter was always the soul of honour in regard to information derived from these private communications, and was generous to the last degree in giving information from his great store of learning, whose value none could estimate higher than we. I should be very glad to know of any publications in England in recognition of his merits.

Hoping this will find you very well, believe me always, very sincerely yours,

Las Vegas, New Mexico, *November 15th*, 1891. Frank Springer.

"ANNALS OF BRITISH GEOLOGY" FOR 1890.

Sir,—It is not my intention to make any comments on the criticisms which the compiler of the volume bearing the above title has thought fit to introduce into the notices of my papers, as those who have even the most superficial acquaintance with the subject therein treated will be able to appreciate the value of such criticisms. When, however, I am deliberately charged with making a blunder, which exists only in the mind of the compiler, it is time to say something. In noticing the fourth part of my "Catalogue of Fossil Reptilia and Amphibia," the compiler of the work in question goes out of his way to state that I have changed the names *Orthocorta* to *Orthopleurosaurus* without giving any reason for so doing. Now (without commenting on the circumstance that he had the reason for this change staring him in the face), if the compiler had taken the trouble to look at the notes at the bottom of the page, he would have seen after the reference to the name *Orthocorta*, the word "Hybrid."

R. Lydekker.

UNCONFORMITIES BENEATH THE CAMBRIAN QUARTZITES IN SHROPSHIRE.

Sir,—In the Geological Magazine (1891), p. 485, is a paper by the Rev. J. F. Blake, in which he challenges some of my criticisms on his work in Shropshire. His chief assertions are the following:

(1). That at Pontsford Hill the Longmynd Rocks in contact with the Rhyolite are altered.

(2). That at Narnell's Rock there is an unconformity separating Cambrian from "Monian" rocks.

(3). That at Charlton Hill the conglomerates and grits are superficial, and are not a part of the Uriconian series.

Paper-contests in geology are rather unsatisfactory work, and I therefore propose to attempt a settlement of these disputed points, and any others that may be agreed upon, in the following manner. A competent geologist, to be selected by Mr. Blake and myself, to visit the ground in our company, and to publish his conclusions. The disputant who is convinced of his error to publish his recantation. The disputant against whom the referee decides in the

majority of cases to pay the travelling expenses of the referee. I am aware that disputes cannot always be settled in this way; but the three sections I have named are so clear and simple, that a third party can hardly fail to come to an immediate decision, and we should select a person whose award would carry weight. If Mr. Blake refuses this challenge, I will offer to take any competent geologist to the sections, and to forfeit five gunieas to a hospital if I fail to convince him.

CH. CALLAWAY.

November 20th, 1891.

"CONCRETIONS" IN MAGNESIAN LIMESTONES.

SIR,—There is another possible method, besides those suggested by Messrs. Garwood and Jukes-Browne, by which the globular and pseudo-coralline and other forms so remarkable in the Magnesian Limestone of Durham may have originated—the mechanical; and this is slightly alluded to by Professor Sedgwick (page 92).

Many years ago a friend presented me with a considerable series of specimens obtained from the neighbourhood of Sunderland; their examination seemed to indicate that their forms were due to mechanical action, but it was difficult to imagine how the principle on which a school-boy's marbles, "alleys, tors and commoners," are formed from cubical fragments of stone, could have been applied by natural means; nor did a visit to the extensive quarries at Fulwell, north of Sunderland, assist in solving the problem. The promontory on which Tynemouth Castle stands may possibly help to afford a solution. The strata forming the base of the cliff consist of Coal-measure Sandstone, on which rests a bed composed of angular fragments derived from the same, and over this the Permian Limestone has been deposited. This Limestone is full of cavities resembling in appearance some examples of vesicular trap.

I would suggest that during the formation of the limestone, and whilst it was still in a more or less plastic state, gases evolved from the decomposition of vegetable matter forming beds of Coal made their way through the basement beds of limestone. Such vesicles as occur at Tynemouth might be expected to have been formed under these conditions, and it is quite possible that the globular forms of the so-called "concretions," which occur near Sunderland, may have originated from a similar cause, though under somewhat different circumstances, such as the amount of gas evolved; the amount to which the lately deposited limestone had consolidated, etc. Whatever was the cause of the fashioning of the globular masses, the same must have been the instrument by which the coral-like forms were shaped.

I much regret being so circumstanced that I could not conveniently carry out a series of experiments to determine the possibility of the globular forms being due to the cause suggested. The only rough attempt made was so far satisfactory that the passage of carbonic acid, generated beneath clay in a plastic state, resulted in the production of many small rounded forms.

BIRKENHEAD, *November*, 1891. CHARLES RICKETTS.

NEEDLESS ALTERATION OF ZOOLOGICAL NAMES.

Sir,—The want of a proper set of recognized canons to regulate the selection and retention of generic and specific names is becoming more and more urgent. We are constantly being told to abandon some well-known name because an older one has been found, or because it was previously given to some other organism; but such reasons are not sufficient by themselves. The author of a British Museum Catalogue has lately attempted to introduce the name of *Meretrix* instead of *Cytherea*, and that of *Lampusia* in place of *Triton*, two well-known genera of Mollusca; but the needlessness of the change has been exposed by writers in the pages of "Nature," and the author in question must be regarded as a culpable "disturber of the public peace" of mind. Such unnecessary interference with names engenders a feeling of opposition against any change of name, even when the change is desirable and well-founded. Cannot the Linnæan and Zoological Societies take common action with the International Geological Congress in establishing an International Committee on nomenclature, to which all new names and all proposed alterations of names might be submitted? The following letter appeared in "Nature" for November, and might be reproduced in every Biological and Geological Magazine.

Exeter, *November* 21. A. J. Jukes-Browne.

Meretrix, Lamarck, 1799, *versus Cytherea*, Lamarck, 1806.

In the notice of Mr. Newton's "List of Mollusca," in "Nature" of October 29 (vol. xliv. p. 610), I read as follows:—"Many old favourites have been thus relegated to obscurity, whilst fresh names, dug up from some forgotten corner, have, by the law of priority, taken their places. Thus, *Meretrix*, Lamarck, 1799, takes the place of his better-known *Cytherea* of 1806, the latter having been applied by Fabricius in 1805 to a dipterous insect."

The Dipteron *Cytherea obscura*, Fab., 1805, was described nine years later than *Mutio obscurus*, Latreille (1796), which is the same species. Meigen, in his principal work (1820), acknowledged the priority, and the insect has been called *Mutio* ever since. As the typical species is the same for both genera, there is no chance whatever for *Cytherea* to be resuscitated, and it may well remain as the name of the Mollusk. I most heartily agree with the opinion of the reviewer, that "it would be an immense gain if every name proposed to be altered had to pass through a regularly-constituted committee of investigation before it was accepted and allowed to pass current." In such a committee, besides *priority*, two other paramount scientific interests should be consulted, and they are—*continuity* and *authority*.

Heidelberg, *November* 1. C. R. Osten Sacken.

OBITUARY.

WILLIAM KINSEY DOVER, F.G.S.

We have to record the death of an old friend, and brother geologist, Mr. William Kinsey Dover, F.G.S., who died at Low Nest, near Keswick, on the 27th of March, 1891, in his seventy-fifth year. After completing his education, Mr. Kinsey was for some years engaged in mercantile pursuits, but he left London in 1855, and entered the Cumberland Militia, in which he served as Ensign (1855), Lieutenant (1861), and Captain in 1865. On his retirement from the Militia in 1868, he devoted himself to Natural

History pursuits, and more lately to palæontology, paying especial attention to the fossils of the Skiddaw Slates, which he collected with great diligence and care, accumulating in time a very fine series of these rare Ordovician treasures. Mr. Dover was elected a Fellow of the Geological Society in 1880, and a member of the Geologists' Association in 1881, taking part in the Lake-District long-excursion of the latter body in that year, as one of its directors. In 1890 Mr. Dover presented his fine collection of Skiddaw Slate Fossils to the Woodwardian Museum, Cambridge, where it forms a most valuable contribution to our knowledge of the Geology and Fauna of the Lake-District rocks.

SIR ANDREW CROMBIE RAMSAY, Knt.,

LL.D., F.R.S., F.G.S.

Born 1814. Died December 9th, 1891.

We regret to record the death of Sir Andrew Ramsay, late Director-General of the Geological Survey, which occurred at his residence, Baumaris, Anglesey, Dec. 9th, 1891, in his 77th year.

He was educated at Glasgow, and was appointed to the Geological Survey of England and Wales in 1841, and became Local Director in 1845. He was nominated Professor of Geology at University College in 1848, Lecturer on Geology at the Royal School of Mines in 1851, and was President of the Geological Society in 1862 and 1863. He was elected a F.R.S. in 1849, and Knight of the Order of St. Maurice and St. Lazarus in 1862, and was elected an honorary LL.D. of Edinburgh in 1866. He received the Wollaston Gold Medal from the Geological Sociey in 1871. On the death of Sir Roderick I. Murchison, Bart., he was made Director-General of the Geological Survey of the United Kingdom, and of the Museum of Practical Geology in 1872. On his retirement from these offices in 1881, he received the honour of Knighthood. He presided over the meeting of the British Association at Swansea in August, 1880. He was an Associate of many foreign societies. Sir Andrew Ramsay is author of "The Geology of Arran," "Geology of North Wales," 1858, 2nd edition 1881; "Old Glaciers of North Wales and Switzerland," 1860; the "Physical Geology of Great Britain," 1878; and of very many memoirs, chiefly on theoretical geology.

His life and portrait appeared in the Geological Magazine for 1882, Decade II. Vol. IX. pp. 289–293.

Dr. Ferdinand von Roemer, Professor of Geology and Palæontology in the University of Breslau, whose Jubilee as Professor it was intended to celebrate on 10th May, 1892, died at Breslau, on the 14th December, 1891, in his seventy-fourth year. Dr. Roemer was elected a Foreign Member of the Geological Society in 1859, and was awarded the Murchison Medal in 1885. We shall give a notice of this distinguished Geologist in the February Number.—Edit. Geol. Mag.